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A SYSTEM FOR SAMPLING, LABELING, AND
DIGITAL RECORDING OF OPTICAL MEASURE-
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Mark R. Weiss

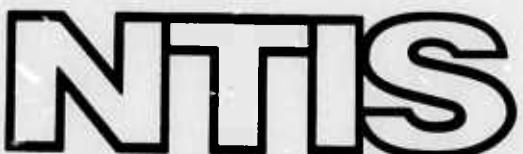
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April 1973



A SYSTEM FOR SAMPLING, LABELING, AND DIGITAL
RECORDING OF OPTICAL MEASUREMENT DATA

Federal Scientific Corporation

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Optical measurement data generated at the Verona Test Site of RADC must be reduced in a computer to extract the desired parameters. These parameters are: angle-of-arrival, phase-structure function, modulation transfer function, and amplitude scintillation. This report describes a system which processes the raw measurement data and generates digital tape recordings suitable for input to a GE 645 Computer.

The system consists of two components. First is an Optical Data Processor (ODP) which reduces the dynamic range required for sampling and recording the raw data, and the storage volume required for the recordings. The ODP operates by performing the initial processing that is required for extracting the optical parameters. For the angle-of-arrival and phase-structure function this consists of measuring the phase angle. For the modulation transfer function, the envelope is extracted. Scintillation data are compressed logarithmically. Suitable automatic gain control, filtering, and shaping circuits are included to maximize the accuracy of the ODP outputs. Two ODP units were constructed, one for a visible light laser and the other for an infrared light laser.

The second component of the system is software which was written for the PDP-8 computer at the test site. These programs control the sampling and recording of the processed data and provide appropriate labels for each data record and data

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13. Abstract (continued)

file. The programs also provide the ability to automatically search for the start of a desired data set and to sample and record the data for a specified interval. Two sets of programs were provided, one for the angle-of-arrival, phase-structure function, and amplitude scintillation data, and the other for the modulation transfer function data.

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FOREWORD

This Final Report describes efforts by Federal Scientific Corporation, 615 West 131st Street, New York, NY, under contract F30602-71-C-0007, Job Order Number 12790208, for Rome Air Development Center, Griffiss Air Force Base, New York. This effort was partially sponsored by the Defense Advanced Research Projects Agency under ARPA Order Number 1279.

Mr. Donald O. Tarazano (OCSE) was the RADC Project Engineer.

This report has been reviewed by the RADC Information Office (OI) and is releasable to the National Technical Information Service.

This technical report has been reviewed and is approved.

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ABSTRACT

Optical measurement data generated at the Verona test site of RADC must be reduced in a computer to extract the desired parameters. These parameters are: angle-of-arrival, phase-structure function, modulation transfer function, and amplitude scintillation. This report describes a system which processes the raw measurement data and generates digital tape recordings suitable for input to a GE 645 Computer.

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TABLE OF CONTENTS

<u>Section</u>	<u>Text</u>	<u>Page</u>
1.0	INTROLUCTION	1
2.0	THE OPTICAL DATA PREPROCESSOR	6
2.1	Design Concepts	6
2.1.1	The Phasemeters	9
2.1.2	The Scintillation Circuit	20
2.1.3	The Modulation Transfer Circuit	20
2.2	ODP Input Signal Requirements	23
2.3	Operation of the ODP Controls	25
2.4	Operation and System Checkout	32
3.0	SYSTEM SOFTWARE	36
3.1	General Requirements	36
3.2	Techniques for Meeting the General Performance Requirements	38
3.2.1	Real-Time Sampling	38
3.2.2	Sampling Accuracy	39
3.2.3	Continuous Sampling and Recording	40
3.2.4	Automatic Processing of Analog Recorded Data	41
3.2.5	Labeling of Records	43
4.0	DESCRIPTION OF OPTICAL 1	45
4.1	The Main-Line Routine	45
4.2	Subroutine to Sample the Data	49
4.3	Subroutine to Write Digital Tape Records	49
4.4	Subroutine to Detect the Start of a Calibration Data Set	50
4.5	Subroutine to Detect the Start of Optical Signal Data	51

TABLE OF CONTENTS (continued)

<u>Section</u>	<u>Text</u>	<u>Page</u>
4.6	Subroutine to Detect One-Second Time Marks	51
4.7	Subroutine for Computing the Sampling Rate	51
5.0	SAMPLING AND RECORDING THE MTF SIGNAL	53
5.1	The MTF Sampling Program	54
5.2	The MTF Sync-Pulse Test	60
6.0	APPENDIX 1 - PIN CONNECTIONS FOR EXTERNAL PHASE-ORIGIN DATA	61
7.0	APPENDIX 2 - LISTING OF OPTICAL 1 PROGRAM FOR SAMPLING AND RECORDING OPTICAL DATA	62
8.0	APPENDIX 3 - LISTING OF PROGRAM FOR SAMPLING AND RECORDING MTF DATA	86

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	The Optical Data Processor, Visible Light System	7
2	Arrangement of Circuit Boards for Servicing the ODP	8
3	Block Diagram - Automatic Gain Control Circuit	11
4	Block Diagram - Input Filtering and Shaping Circuit	13
5	Block Diagram - $\Delta\phi$ Phase Measurement Circuit	15
6	Block Diagram - $\Delta\Delta\phi$ Phase Measurement Circuit	18
7	Block Diagram - Integrated Phase-Change Measurement Circuit	19
8	Idealized MTF Waveform	21
9	Block Diagram - MTF Circuit	22
10	Executive Routine for OPTICAL 1	46
11	Program Flow-Path and Timing of MTF Sampling Routine	55

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1	Square Wave Input Signal Frequencies	14
2	Resolution and Range of Optical Phase Measurement Systems ...	16

1.0 INTRODUCTION

The work described in this report was carried out under Air Force Contract F30602-71-C-0007, in support of laser propagation experiments being conducted by Rome Air Development Center. An immediate objective of these experiments is to measure several of the effects of a non-uniform atmosphere on the transmission of laser light.

The role of Federal Scientific Corporation was to provide RADC with a system for recording the desired optical measurement signals onto digital magnetic tape for analysis by a computer.

The system being used by RADC to obtain optical data includes a telescope to collect the laser light, a rotating reticle with a different scanning pattern for each optical function to be measured, and optical/electrical transducers to convert the optical measurements to electrical signals. The system for recording the data consists of a PDP-8 computer which includes a 16-channel analog signal multiplexer, an analog-to-digital converter, and a digital tapewriter. An instrumentation tape recorder is available for recording optical data signals in analog form.

The technical objectives of the contract called for the digital recording of four kinds of optical measurement data: angle-of-arrival, phase-structure function, modulation transfer function, and amplitude scintillation. The signals which convey angle-of-arrival data consist, ideally, of a pair of constant frequency square-waves with variable relative phase angle. The desired information is contained in the phase angle. Phase-structure function is represented by a similar set of square waves. A single square-wave of varying frequency and amplitude conveys the modulation-transfer-function. Here, the envelope of the signal contains the

information. Finally, amplitude scintillation is represented directly by a noise-like AC signal which is centered about some DC level.

The data signals may be obtained live from the optical system, or they may be reproduced from analog tape recordings made on the instrumentation tape-recorder. In either case, it is necessary to preprocess them before they can be sampled, converted to digital form, and recorded onto magnetic tape in computer compatible format.

The live signals possess a far wider amplitude and frequency range than can be recorded onto analog tape by the instrumentation recorder, or than can be sampled, converted, and recorded onto digital tape. For example, at a reticle rotation speed of 300 rpm, the frequency of the phase-structure function square wave is 32 kHz. However, the upper bandwidth of the instrumentation recorder is 20 kHz when recording in the FM mode (as is required for accurate preservation of the signal waveform). At this same speed, the MTF bandwidth is likely to exceed 20 kHz (assuming a spot size of about 80 microns for visible laser light). Obviously, at the highest reticle speed, 1800 rpm, the problem of recording the optical data signals becomes six times worse.

Similar difficulties would occur if the data signals were to be sampled and recorded live. By the Nyquist criterion, the signals must be sampled at twice the frequency of the highest frequency component. The fastest that the PDP-8 computer at the test site can sample signals, store the samples in a data buffer, and periodically unload the buffer onto magnetic tape is about 10 kHz. Consequently, it is not possible to record, either in analog or digital mode, the live data signals for two of the three reticle speeds.

To get around this problem it is necessary to process the signals before sampling or recording them. The ideal in the preprocessing of information-bearing signals is to extract from them the essential information, leaving behind the carrier and other incidental components. Failing this, the next best preprocessor is one which transforms the signals so as to compress the amplitude and/or frequency range without at the same time losing or altering the essential information. For example, a highly accurate logarithmic compressor can be used to reduce the amplitude dynamic range which is required to record a signal.

The preprocessor which was developed under this contract uses both data extraction and signal transformation techniques. For the angle-of-arrival and phase structure function, the information contained in the relative phase-angles of the square-waves is extracted by high-speed phase meters. For scintillation, the wide amplitude-dynamic range is compressed by use of a linear-to-logarithmic converter. The information in the MTF is conveyed by the envelope of the variable frequency square-wave. This parameter is processed by peak detecting the signal, and passing the detector output through a 3.5-kHz wide filter. As a result, the original signal waveform is preserved at low frequencies and replaced by an increasingly smooth envelope at higher frequencies.

In addition to processing the data signals as described, the pre-processor generates signals which can be used to calibrate the outputs of the phasemeters. It also provides automatic gain control of the input signal to reduce the effects of signal amplitude fluctuation (scintillation) on the accuracy of the phase meters and the MTF system.

Two preprocessor systems were constructed under this contract: one for use with a visible-light laser and the other for an infrared laser. They are discussed and described in detail in Section 2.

The processed data signals, whether obtained live or from analog tape recordings, are sampled, the samples converted to binary numbers, and these written onto magnetic tape in computer compatible format. The sampling, digital conversion, and recording of the data is performed by the PDP-8 system under control of assembly language programs written under this contract. In addition to these operations, the programs also provide sufficient information with each data record and each file of records to identify the data and the conditions of the test, and to simplify the later computer analysis of the data. Finally, the programs include options which permit the user to select the start and stop times for the sampling and recording of data.

Two programs were provided. One of these is used for the angle-of-arrival, phase-structure function, and scintillation data. The other program is for sampling and recording the MTF data. These are discussed in Section 3 and described in Sections 4 and 5.

In addition to the programs cited above, several programs were developed for sampling, recording, and labeling meteorological measurements such as temperature, wind velocity, etc. In these routines, the number of parameters to be sampled and the sampling rate are set by the user, via the teletypewriter, at the start of a run. If desired, these programs can be used to sample and record the scintillation data simply by setting the sampling rate to 6000 Hz, to insure capturing scintillation components up to 2000 Hz. (To avoid any possibility of spectrum fold-over effects, it is recommended

that data which are sampled in this manner be low-pass filtered, with the filter breakpoint set at about one-third the sampling rate.)

2.0 THE OPTICAL DATA PREPROCESSOR

2.1 Design Concepts

The Optical Data Preprocessor (ODP), shown in Figure 1, receives the data signals which are generated by the telescope optical system and its associated electronics package. It processes them and provides as outputs versions of these signals which have been made compatible with the data handling capabilities of the analog and digital recording systems at the Verona test site. Two ODP's are provided, one for the infrared laser measurements and the other for the visible light data. Each ODP consists of three main systems: a pair of phasemeters for angle-of-arrival and phase-structure-function measurements, a peak detector for the MTF signal, and a logarithmic compressor for the amplitude scintillation signal. Also included are systems for calibrating the phase-angle measurements and for reducing the effects of amplitude fluctuations on the phase-angle and MTF measurements. In addition, timing signals are provided which mark the completion of each successive phase-angle measurement. These can be used to synchronize the sampling of the phase-angle data by the computer. Finally, a pulse train with a prf of one pulse per second is generated for use in timing the computer's sampling and recording of the preprocessor outputs.

The various circuits are fabricated on three 14 x 14 inch boards which are mounted horizontally in a 5-inch high frame. The three connectors into which the boards slide are wired in parallel, permitting the boards to be stacked in any sequence. A fourth connector, facing upward, is provided to facilitate servicing of the boards, as shown in Figure 2. As described in Section 2.3, suitable controls and indicators are provided on the front panel for the selection and monitoring of the various functions provided by

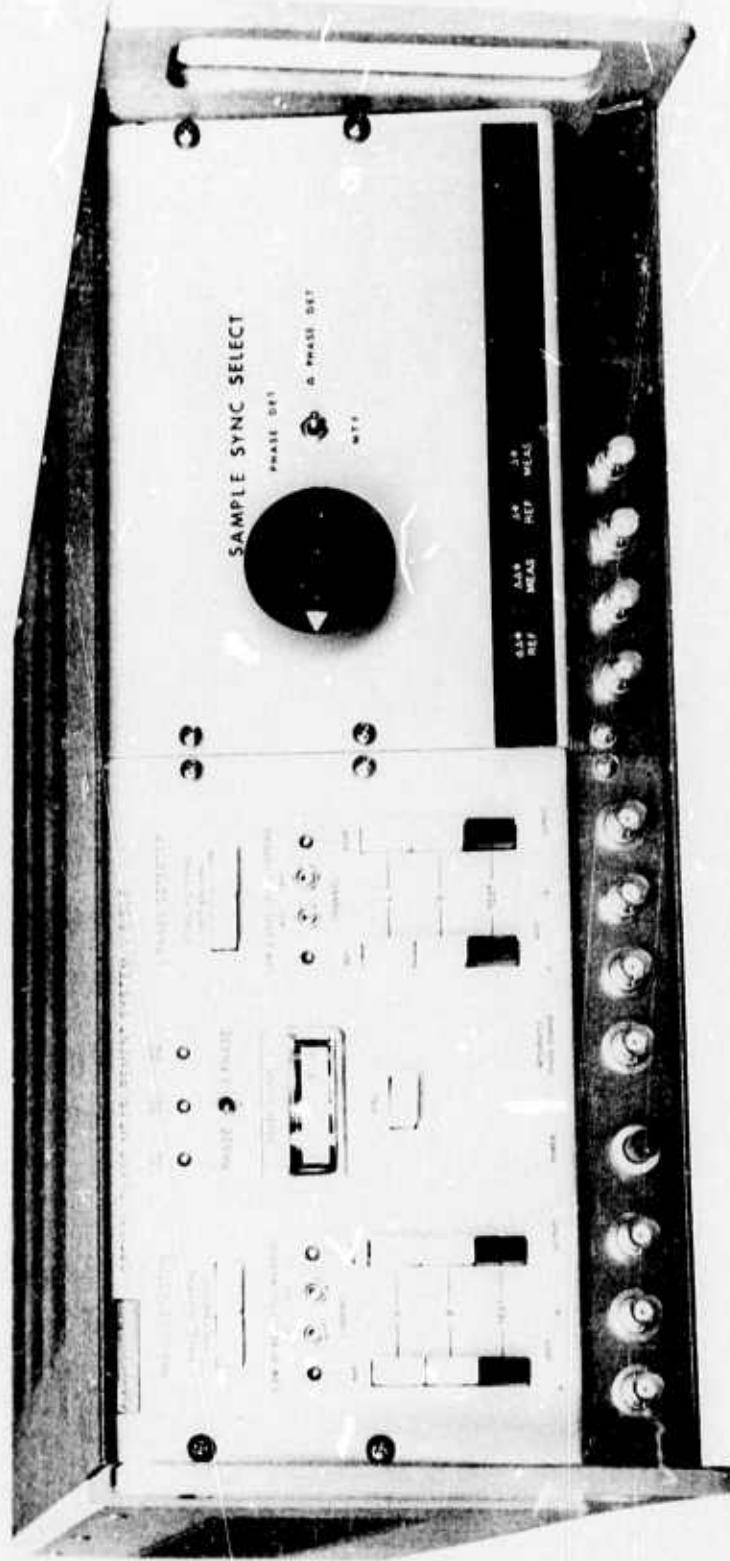


FIG. 1 THE OPTICAL DATA PROCESSOR, VISIBLE LIGHT SYSTEM

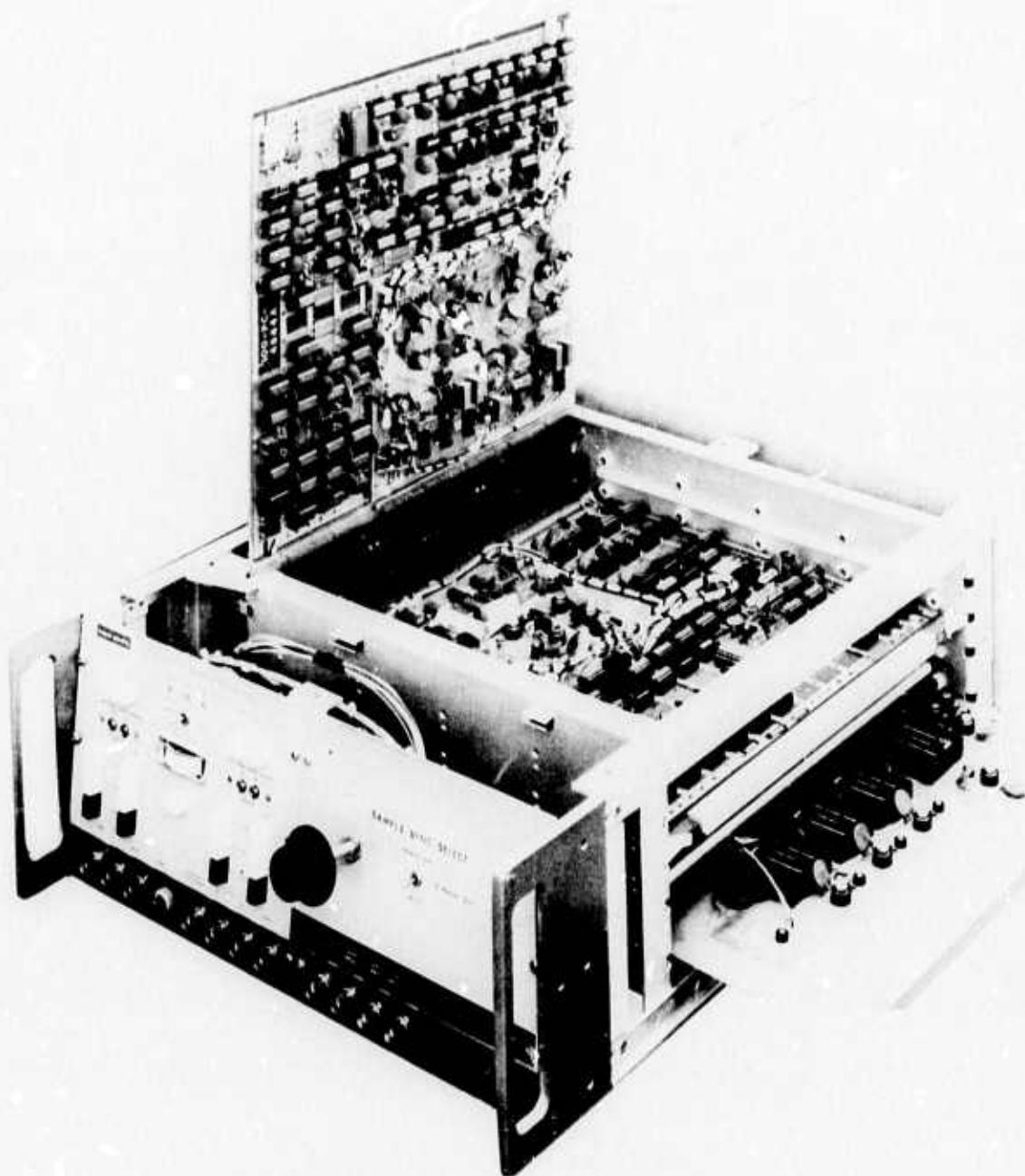


FIG. 2 ARRANGEMENT OF CIRCUIT BOARDS
FOR SERVICING THE ODP

the ODP. Power for the unit is provided via a cable from a remotely located power supply.

2.1.1 The Phasemeters

The input to either the phase-structure function ($\Delta\phi$) or angle-of-arrival ($\Delta\Delta\phi$) phasemeter consists of two signals, one a reference and the other the data. For both functions the reference signal is obtained from a point-light source, within the telescope, that is chopped by a uniformly spaced grating or pattern on a rotating reticle. A different grating is used for each function. For the $\Delta\Delta\phi$ function, the data signal is obtained by passing the received laser light through the appropriate pattern on the reticle. For the $\Delta\phi$ data, the light that is chopped by the reticle grating is not the received light itself, but a spatial interference pattern derived from it.

Ideally, these signals should appear as constant amplitude, constant frequency square waves, with only the relative phase angle between the data signals and the reference changing. In practice, the signals are constant in frequency, but their shapes deviate greatly from the ideal. The references are constant in average amplitude, but exhibit a slightly rounded top and bottom, and clearly rounded sides. Due to the limited intensity of the reference light source, these signals are accompanied by a small, but not negligible amount of noise that is generated by the photomultiplier. The data signals show significant variations in amplitude, are much more rounded, and exhibit a signal-to-noise ratio that ranges from about 15dB to about 6dB.

To improve the quality of the input signals before attempting to use them in phase angle measurements, the phase meters are preceded by an input section which consists of AGC circuitry, and filtering and shaping circuitry.

These are described in Sections 2.1.1 and 2.1.2 below. The phasemeters themselves are described in Sections 2.1.3, 2.1.4, and 2.1.5.

2.1.1.1 The AGC Circuits

The function of the AGC circuits is to reduce those variations in the amplitudes of the data signals which are due to variations in the intensity of the received laser light. Since these variations are represented by the AC component of the scintillation signal, the AGC circuits are designed to extract and use this component.

A block diagram of the AGC system is shown in Figure 3. The scintillation signal which is generated during infrared measurements is chopped in the optical system before being converted to an electrical waveform. Consequently, the first operation in the AGC system of the Infrared ODF is to detect both the positive and negative peaks of the scintillation signal and sum and store them in a sample-and-hold circuit. The input to the negative peak detector is inverted before detection so that the two peak values can be added constructively. The summed peaks are then sampled and applied to a variable gain amplifier (actually a multiplier/divider module) whose output is the desired AGC signal.

The sampling control signal is obtained from the optical system. It is amplified and applied to a Schmitt Trigger-Mono system. This circuit first generates a sampling pulse to transfer the current AGC data to the output amplifier. It then generates a discharge pulse to remove the data from the sample-and-hold input to permit storage of the next detected peak amplitude.

For the visible laser experiments the scintillation signal which is provided by the optical system is not chopped. Therefore, none of the

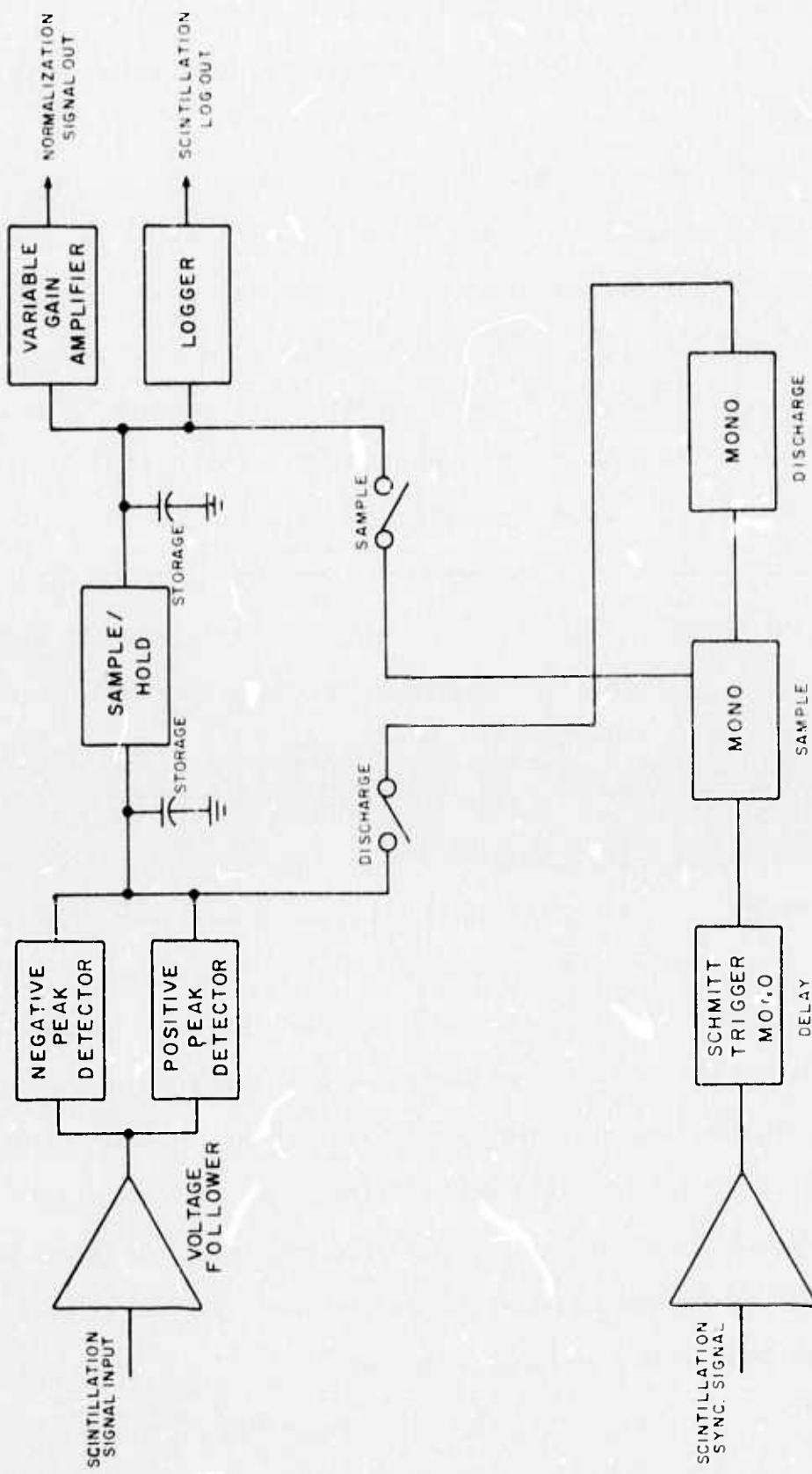


FIG. 3 BLOCK DIAGRAM - AUTOMATIC GAIN CONTROL CIRCUIT

sampling circuitry described above need be employed in the Visible ODP. Instead, the signal is simply rectified continuously and then applied directly to the output amplifier.

To reduce the amplitude variations in an incoming data signal, the detected scintillation signal is applied to the divisor input of an analog multiplier/divider module and the data signal is applied to the normal input. Since the amplitude of the data signals vary in proportion to the scintillation signal, a data signal can be regarded as a constant, K, multiplied by the scintillation signal. By taking the data signal (K)(Scint) and dividing it by (Scint), the scintillation factor drops out and the signal amplitude becomes constant. Various trimmer adjustments are provided to insure that the constant numerical ratios are correct, so that there is neither gain nor loss in the system and everything tracks properly. When this condition is achieved, the AGC system will correct for amplitude changes over a 20dB range, within a scintillation bandwidth of 3kHz.

2.1.1.2 The Filtering and Shaping Circuits

The filtering and shaping circuits, illustrated in block diagram form in Figure 4, are designed to maximize the accuracy of the phase-angle measurements by reducing both the noise level and the rise and fall times of the input "squarewave" signals. After being corrected for amplitude variations due to scintillation, the input signals are applied to an IC voltage follower and thereafter to a two-pole active filter. The filter's center frequency is switched, in accordance with the rotational speed of the reticle, to correspond to the expected frequency of the input signal. A list of these frequencies is presented in Table 1, below.

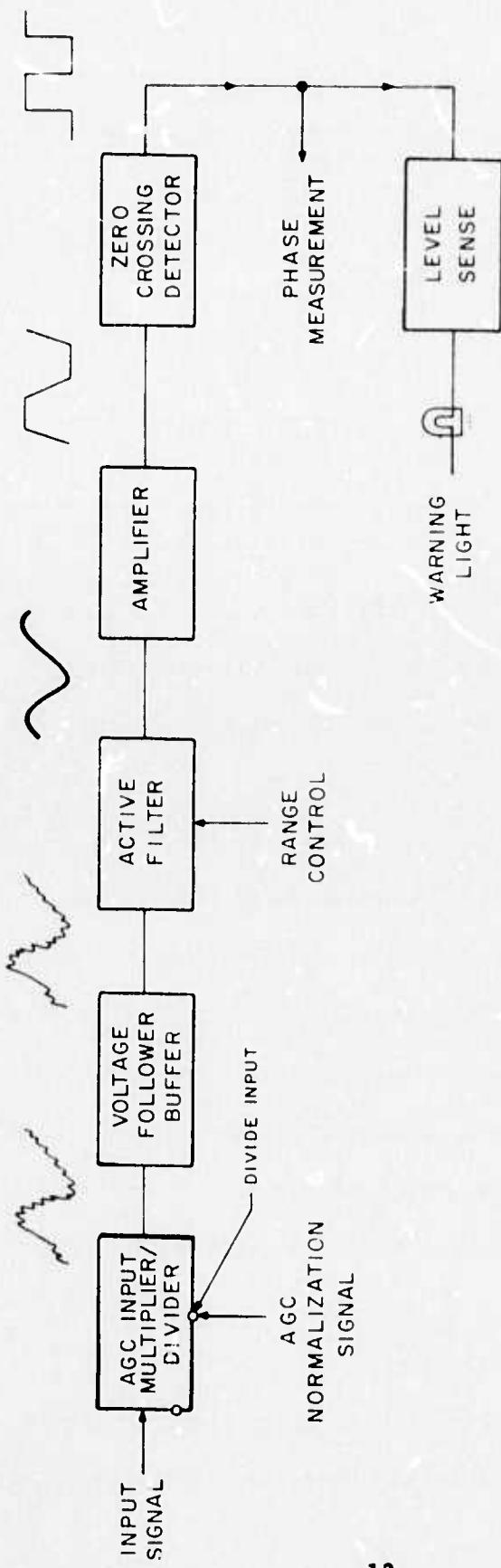


FIG. 4 BLOCK DIAGRAM - INPUT FILTERING AND SHAPING CIRCUIT

TABLE 1
SQUARE-WAVE INPUT SIGNAL FREQUENCIES

Signal	System	Reticle Speed (rpm)	Frequency kHz
$\Delta\phi$	Visible	1800	192
		300	37
		60	6.4
	Infrared	1800	28.2
		300	4.7
		60	0.94
$\Delta\Delta\phi$	Both	1800	0.96
		300	0.16
		60	0.032

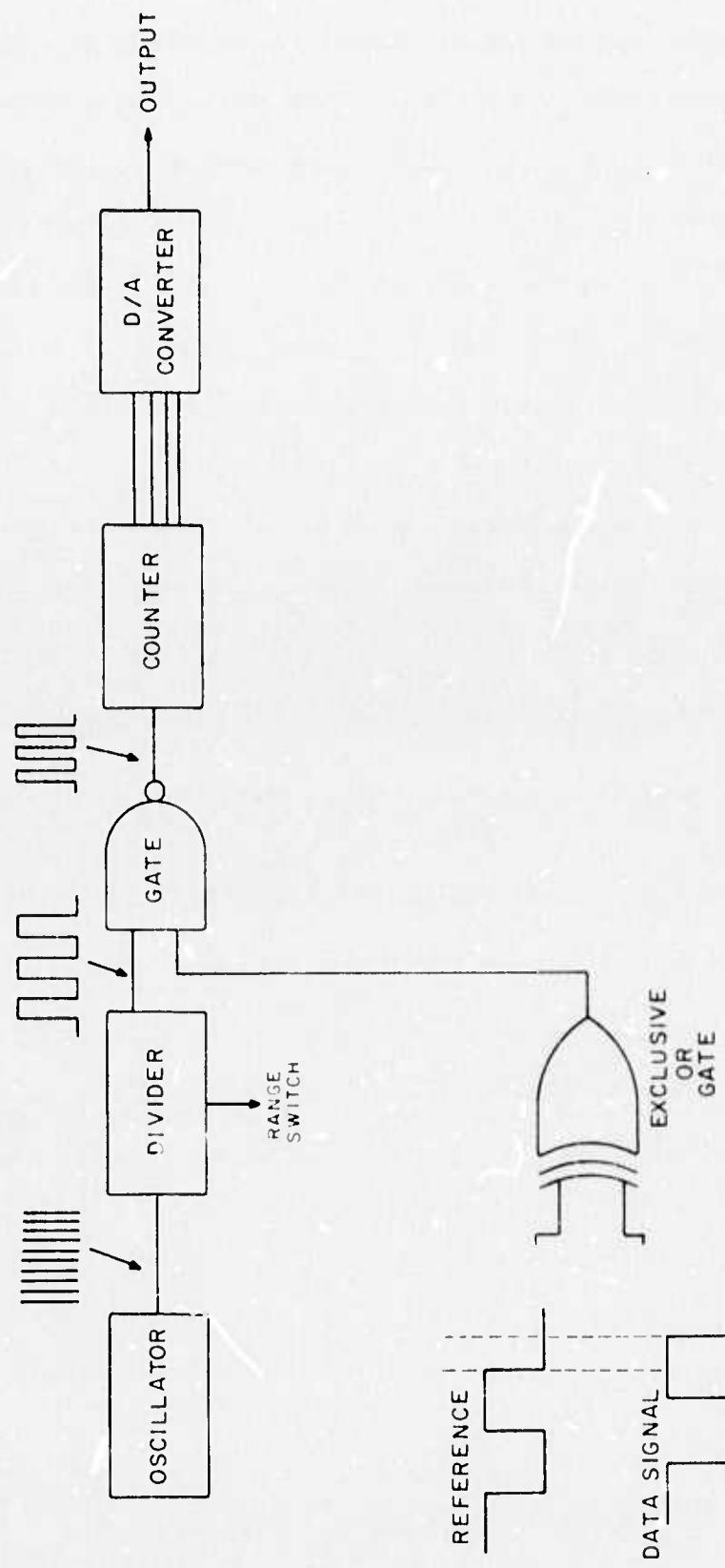
The filter has a bandpass characteristic with a constant Q of about 10. This helps to remove much of the noise that accompanies the signal.

After passing through the filter, the signal is amplified and applied to a zero-crossing detector. The detector output, a square-wave of the same frequency as the input signal, but with much less noise and a minimum of phase jitter, is applied to the phase measurement circuitry.

The amplitude of the output square-wave is compared to the minimum level which will permit reliable phase-angle measurements to be made. Whenever the amplified and shaped square-wave fails to exceed this threshold, a level sensing circuit generates a signal which produces a special negative voltage at the phasemeter output. This signal also illuminates a light on the front panel to warn the operator that the measurement conditions are poor.

2.1.1.3 $\Delta\phi$ Phase Measurement Section

The $\Delta\phi$ phase measurement circuit, illustrated in Figure 5, operates by measuring the time difference between successive zero-crossings of the

FIG. 5 BLOCK DIAGRAM - $\Delta\phi$ PHASE MEASUREMENT CIRCUIT

reference and measurement signals. A high-speed clock signal is generated and divided down to an appropriate frequency. A counter is started on one edge of the reference signal and stopped on the corresponding edge of the measurement signal. The number of clock cycles counted is thus proportional to the phase difference between the two signals. The frequency division of the high-speed clock is selected such that the frequency of the counted clock signal is proportional to the selected RPM range. By this means, the phase-measurement range is held constant at 360 degrees, even though the absolute time interval between the signal transitions varies according to the input frequency. Similarly, the minimum measurable phase difference will be independent of the reticle speed, as shown in Table 2. The digital number proportional to the measured phase difference is converted to analog form by a D/A converter and applied to the front panel output jack.

TABLE 2
RESOLUTION AND RANGE OF OPTICAL PHASE MEASUREMENT SYSTEMS
(In Degrees)

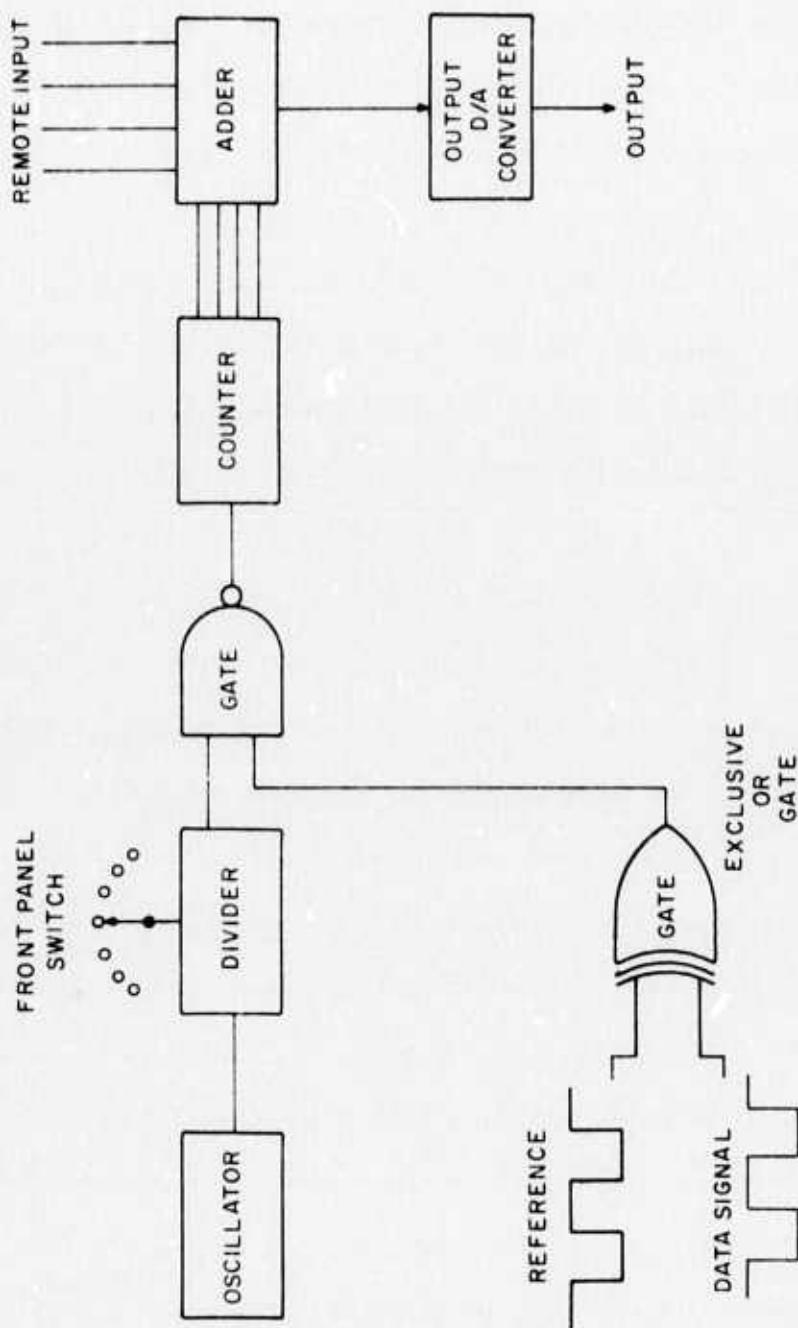
Reticle Speed (RPM)	$\Delta\phi$ Resolution		$\Delta\Delta\phi$	
	Visible	Infrared	Resolution	Range
60	6.55	0.97	0.136	136
300	6.55	0.97	0.0225	22.5
1800	6.55	0.97	0.0045	4.5

2.1.1.4 $\Delta\Delta\phi$ Phase Measurement Section

The operation of this circuit (illustrated in Figure 6) is similar to that of the $\Delta\phi$ phasemeter except that the divider is eliminated so that the same clock frequency can be counted on each range. Thus, the measurable phase-angle range varies with reticle speed, as does the resolution of the measurement (see Table 2 above). To permit the tradeoff between range and resolution to be varied, an additional clock-frequency divider was installed which is variable from the front panel and gives selectable resolution in factors of two. This circuit is independent of the RPM range to which the device is set. An adder is provided to enable the phase origin to be set remotely. The pin connections for the external phase-origin data are listed in Appendix 1.

2.1.1.5 Integrated-Phase-Change Measurement Circuitry

This circuit is employed to count the number of phase rotations between the two input signals in the $\Delta\phi$ phase measurement section. It does this by sensing when the phase changes from near plus 180 degrees to near minus 180 degrees, or vice versa. To perform this function, a counter similar to that in the phase-measurement section is employed, although it has less resolution. Each phase measurement produces a given analog output voltage which is applied to a differentiator, as shown in Figure 7. As each measurement is made, the change in phase is differentiated. The height of the resulting pulse will be proportional to the magnitude of the phase change. A small change produces a small pulse, while a full-scale change, corresponding to a rotation, produces a large pulse. The pulse is threshold detected to discard small changes, and polarity detected to determine the direction of rotation. The pulses are then applied to an up/down counter to keep track of how many pulses of each polarity have occurred. The output of

FIG. 6 BLOCK DIAGRAM - $\Delta\Delta\phi$ PHASE MEASUREMENT CIRCUIT

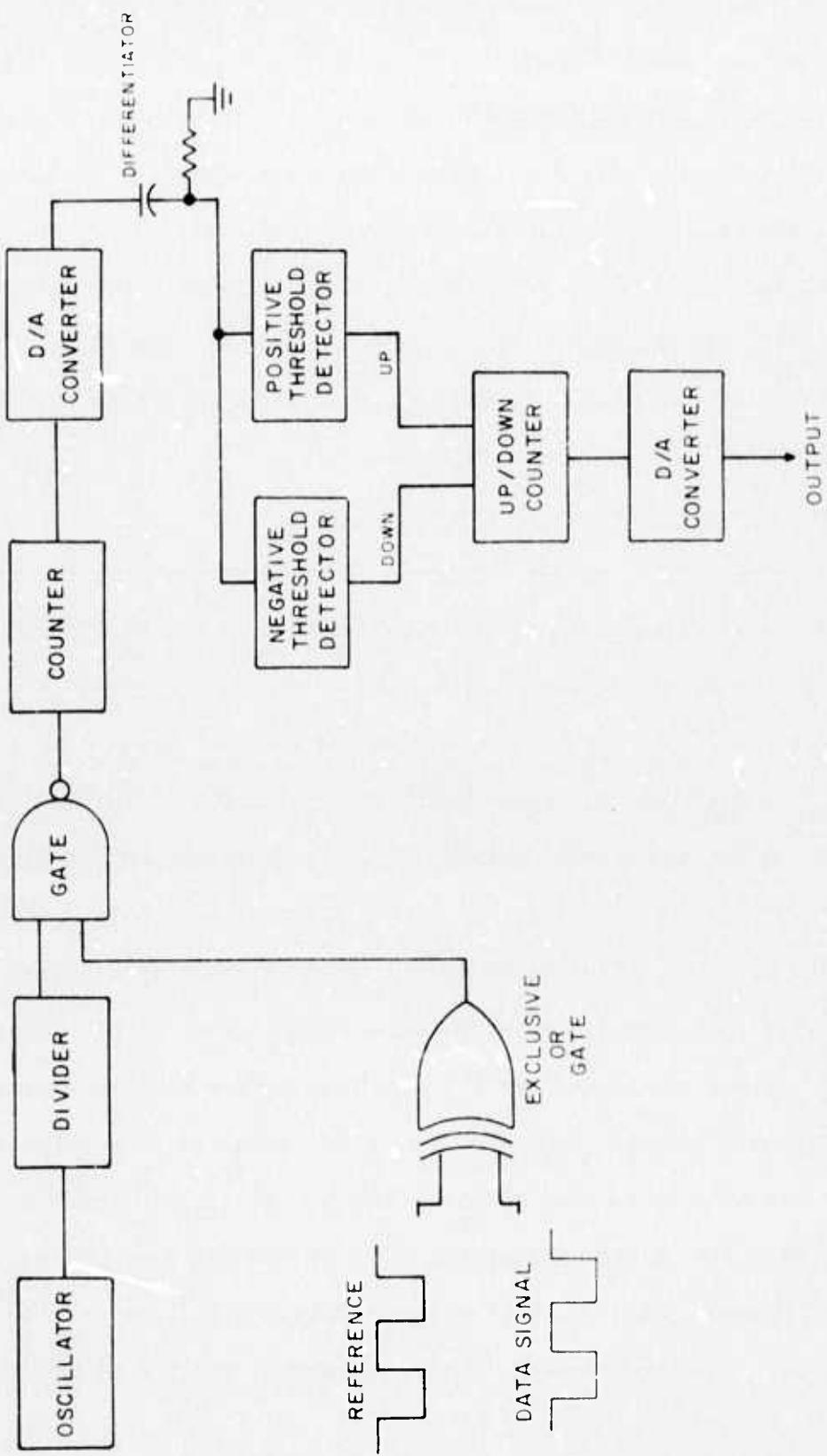


FIG 7 BLOCK DIAGRAM - INTEGRATED PHASE-CHANGE MEASUREMENT CIRCUIT

this up/down counter is applied to a D/A converter, whose output corresponds to the Integrated Phase Change.

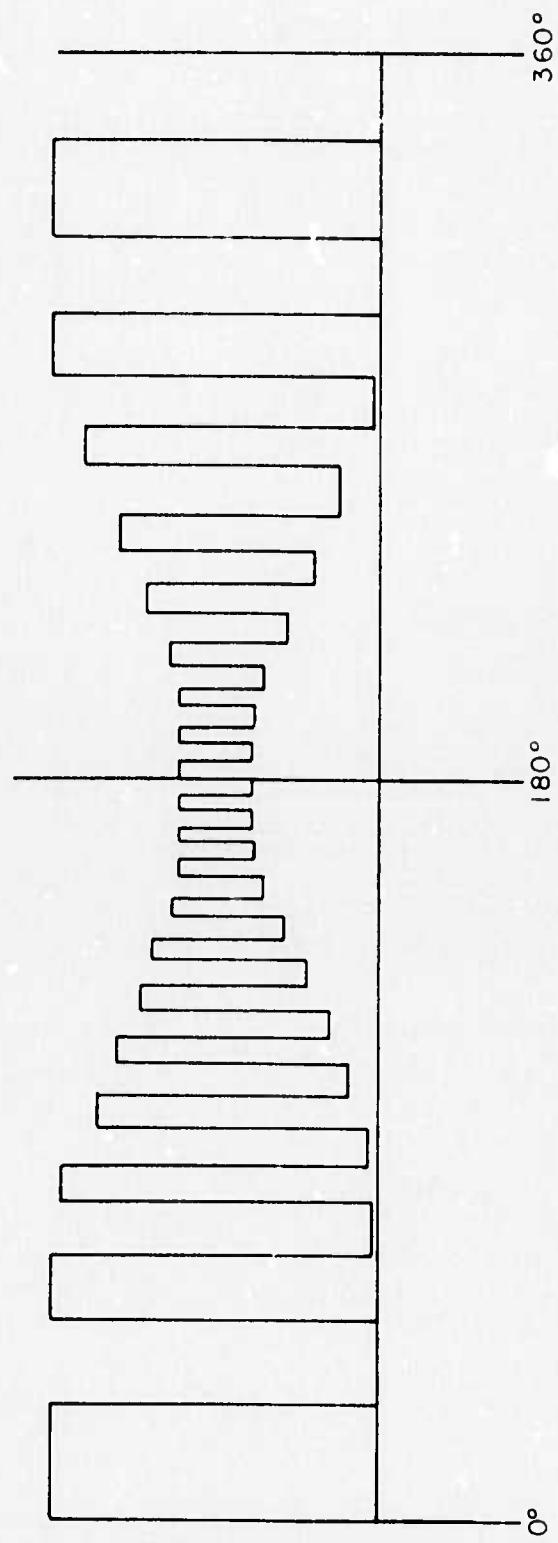
2.1.2 The Scintillation Circuit

In accordance with the requirements for maximizing the dynamic range for analysis of the scintillation data, the scint signal which is extracted by the AGC circuits is applied to a logarithmic compression module (see Fig. 3). The resulting signal easily can be recorded within the 40-dB dynamic range of the Ampex instrumentation recorder or within the 9-bit sampling range which is used by the PDP-8 programs.

2.1.3 The Modulation Transfer Function Circuit

The Modulation Transfer Function (MTF) is conveyed by the envelope of a square-wave signal such as is illustrated in Figure 8. The MTF signal provided by the optical system is centered about some DC level. The maximum waveform amplitude occurs when all of the received light passes through a slit on the MTF track of the scanning reticle, the minimum when all of it is blocked by the space between two slits. The minimum peak-to-peak variation occurs when about half of the light is blocked and half passes through.

The envelope is extracted by use of the circuit illustrated by the block diagram in Figure 9. After being amplified, the raw MTF signal is applied to an AGC multiplier/divider module to remove amplitude variations caused by scintillation. Following this, the signal is peak-detected and then smoothed by a short time-constant filter. The filter break-point is chosen to pass all of the information which is likely to be present in the envelope. However, since part of the square-wave signal is at frequencies which are below the break-point, the corresponding portion of the extracted



RETICAL ROTATION ANGLE

FIG 8 IDEALIZED MTF WAVEFORM

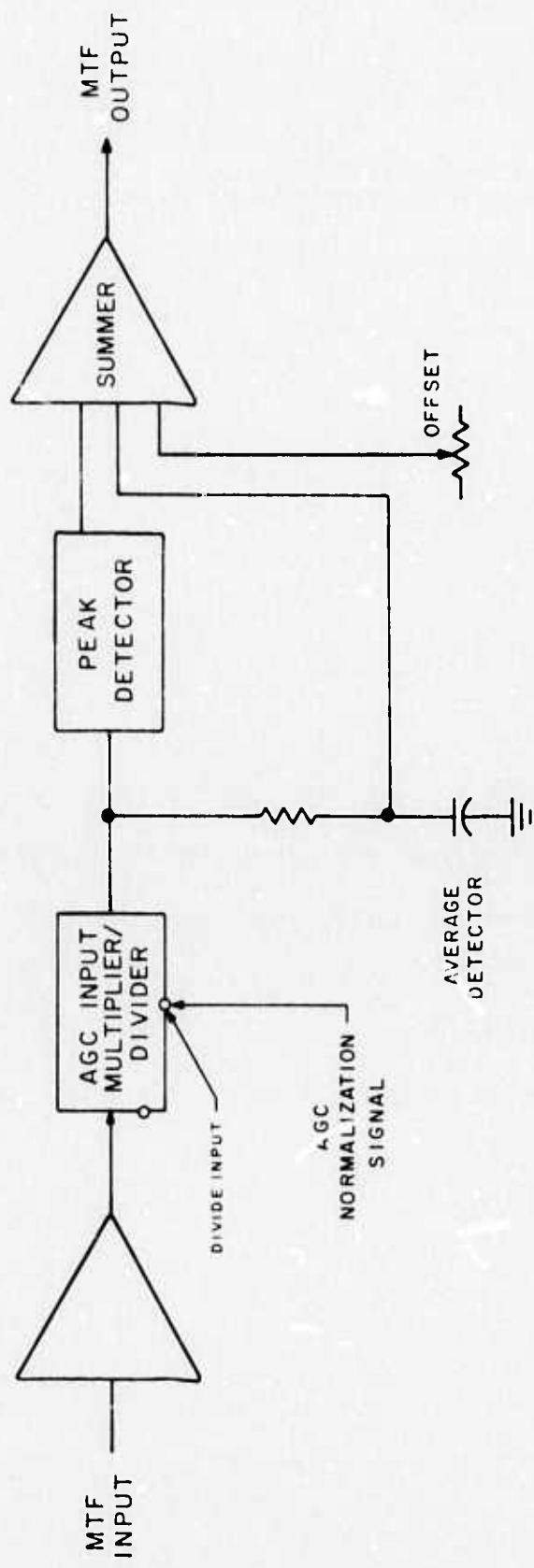


FIG. 9 BLOCK DIAGRAM - MTF CIRCUIT

MTF envelope exhibits a square-wave component. As described in Section 5, the program for sampling the MTF is designed to complete the extraction of the envelope.

An offset is provided at the input to the output summing amplifier so that the output level with no signal input is -1 volt, and with maximum input is +1 volt. An additional offset level is provided to zero-out any long-term variation in the DC or average DC level of the input signal.

2.2 ODP Input Signal Requirements

As the optical phase measurement system is just that - a phase measurement system, it should be relatively indifferent to the amplitude of the input signals. To achieve this independence, a fairly complex AGC (automatic gain control) system is employed which takes an independent sample of the signal amplitude and varies the system gain in a manner designed to present a constant level to the input signal processing circuitry. After filtering, the signal is clipped so that only the phase information is recovered.

In view of this, the signal levels given below are purely nominal, a variation of ± 20 dB may be expected in normal operation.

<u>SIGNAL NAME</u>	<u>NOMINAL LEVEL</u>
$\Delta\phi$ PHASE MEASUREMENT REFERENCE	0.1V RMS
$\Delta\phi$ PHASE MEASUREMENT DATA	0.1V RMS
$\Delta\Delta\phi$ PHASE MEASUREMENT REFERENCE	0.1V RMS
$\Delta\Delta\phi$ PHASE MEASUREMENT DATA	0.1V RMS
SCINTILLATION	Varies from 1 to 10V
MTF INPUT	0 to 5V (centered about 2.5V)
MTF SYNC	Greater than 1 volt

OTHER SYNC SIGNALS	TTL Logic Levels (low less than 0.8V; high greater than 2.1V).
REMOTE CONTROL SIGNALS	SWITCH CLOSURE TO +5V or Ground
REMOTE ORIGIN SET	TTL Levels

OUTPUT SIGNALS

EXPECTED CHARACTERISTICS

PHASE MEASUREMENT OUTPUT ($\Delta\phi$ or $\Delta\Delta\phi$)	+2V to -2V nominal, depending upon the input phase relationship
--	---

(Note that this signal will assume a voltage of about -5 if either the input data or reference signal is insufficient for a valid output. If this occurs, the associated low-signal warning light on the front panel of the ODP will be illuminated.)

INTEGRATED PHASE CHANGE OUTPUT

+5 to -5V, depending upon number and direction of phase rotations in $\Delta\phi$ Phase Measurement channel.

SCINT LOG OUT

$\pm 1V$, depending upon scintillation signal amplitude

MTF OUT

$\pm 1V$

COMPOSITE SYNC OUT

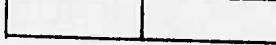
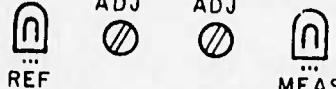
TTL LEVEL

INPUT SIGNAL VIEWING JACKS

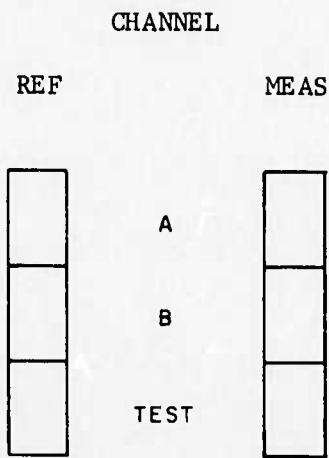
Approximately 0.1V square wave

2.3 Operation of the ODP Controls

The discussion below applies equally to the Infrared and Visible ODP units, since the front panel configurations are nearly identical. It is assumed that the optical system is applying the appropriate signals to the various inputs. The controls or indicators that are sketched below correspond roughly in appearance and layout to their counterparts on the ODP unit. (See the photograph of the VISIBLE ODP, Fig. 1, for comparison.)

<u>CONTROL NAME</u>	<u>FUNCTION OR INDICATION</u>
(Phase detector control group: left side of panel for $\Delta\phi$ phase measurement, right side for $\Delta\Delta\phi$)	
SIGNAL FILTERING DIRECT BANDPASS 	Depressing the BANDPASS button routes the input signal through that input filter whose center frequency is equal to the expected value of the input frequency. Depressing the DIRECT button bypasses this filter.
LOW SIGNAL LEVEL WARNING 	This group is used to indicate that the level of the incoming signal is insufficient to properly activate the measurement circuitry. The left hand light-emitting diode becomes illuminated when the signal in the reference channel is too low, the right hand LED lights when the measurement signal is

too low. The two screwdriver-adjust potentiometers set the warning level for their associated LED indicators.



THIS group of switches routes the input signals to their appropriate channels. The left hand pushbutton group selects the input from either the "A" or the "B" input connector and routes it to the reference channel. The right switch group selects the input from either the "A" or "B" connector and routes it to the measurement channel. Note that it is possible to have the same signal going to the reference and the measurement input, thus giving a quick check on system stability and symmetry.

60 RPM	300 RPM	1800 RPM

This group of indicators show to which rotation speed of the reticle the system is switched. There is no control function associated with them, since they are switched externally by the FSC supplied switch. They also can be switched by the optical system. A con-

nector is provided on the back of the ODP for this purpose. The appropriate connections are:

<u>Signal</u>	<u>PIN</u>
1800 rpm	AA
300 rpm	BB
60 rpm	CC
Common	DD

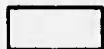
Δ PHASE  $\Delta\Delta$ PHASE

PHASE OUTPUT

METER

The toggle switch and meter are used to give a gross indication of system operation. The switch connects the meter to either the $\Delta\phi$ Phase Detector output, or to the $\Delta\Delta\phi$ Phase Detector output, and the meter indicates the DC voltage present at the selected output. For rapidly changing input signals, the indication is meaningless, as the meter will remain approximately centered. However, a check of operation can be made by connecting a reference signal and a manually varied measurement signal to the input. The meter will then give a rough indication of the phase difference between the two applied signals.

CAL



Depressing this momentary pushbutton applies a step-variable phase signal at the appropriate frequency to the system inputs, bypassing the front panel connectors. This signal is used for automatic calibration of the system before and after the ODP is used to process received optical data.

SAMPLE SYNC

$\Delta\phi$

$\Delta\Delta\phi$

MTF

This three-position toggle switch selects which of the three possible sample-sync-pulses is applied to the rear panel composite-sync output jack. Note that this switch is effective in the calibration mode. However, when in CAL, the output-sync pulses are inverted.

POWER



THIS pushbutton switch is used to apply power to the unit. Depressing it causes its internal lamp to become illuminated, thus indicating that power is indeed applied. Redepressing this control turns the lamp off and disconnects power.

LOCATION - LEFT HALF PANEL

INPUT

A



B



These BNC connectors are used to apply signals from the optical system to the measurement system. Measurement and Reference channels are interchangeable at this point. The selection of which channel is routed to the Reference input is made in the switch group immediately above the connectors. The left hand jacks are for the $\Delta\phi$ phase measurement signals, the right hand jacks are for the $\Delta\Delta\phi$ phase measurement signals.

OUTPUT



The jack immediately to the right of the two input jacks is the output jack for the same function.

INTEGRATED PHASE CHANGE



This BNC connector provides a DC signal whose level is proportional to the number of times the $\Delta\phi$ phase measurement signal has rotated 360 degrees with respect to its reference signal since the last calibration cycle.

LOCATION - RIGHT HALF PANEL

$\Delta\phi$
MEAS



$\Delta\phi$
REF



$\Delta\Delta\phi$
MEAS



$\Delta\Delta\phi$
REF



These BNC jacks are isolated viewing ports to enable the operator to determine if the processed signals are of adequate quality. The test point is located immediately after all analog processing (i.e., AGC, filtering, and shaping) has taken place. Thus the signals should appear to be square waves with no ragged edges.

LOCATION - REAR PANEL

PHASE DET



A INPUT



B



OUTPUT

In each case, the BNC jack in the left hand drawing is wired in parallel to the identically named jack on the front panel, and performs the same function. This is done as a convenience feature. For obvious reasons, one should not connect two different signals to the front and rear panel input connectors. If the signals are connected to the rear panel, it is permissible to view them from the front panel with an oscilloscope.

INTEGRATED PHASE CHANGE



COMPOSITE SYNC OUT

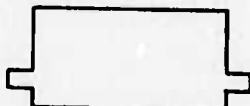


This jack provides the sync as selected by the front panel switch (see page 28).

	MTF		
INPUT	SYNC	OUTPUT	
			<p>These three jacks are for the Modulation Transfer Function signals. The input jack accepts the raw signal, the output jack provides the processed output. The Sync signal is used as a reference and may be applied to the composite sync output jack by means of the front panel control. The presence or absence of this synchronizing signal does not affect the processor in any way.</p>

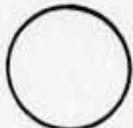
SCINTILLATION			
INPUT	SYNC	OUTPUT	
			<p>The scintillation signal is used by the AGC system to adjust the amplitudes of the other input signals. It is applied to the Input jack (left). The Sync input is required only in the Infrared Measurement System, where it is used as a reference for sampling the scintillation signal. The Output jack provides a signal proportional to the Log of the Scintillation input signal, suitable for recording by the Ampex FR-100, or sampling by the PDP-8.</p>

DC INPUT



These three jacks are for connecting the power supply. The DC input jack receives the various DC voltages from the power supply unit.

AC OUTPUT



The AC input jack is plugged into a source of 115VAC 60Hz, and is switched by means of the power on/off switch to the AC Output jack, which supplies 115 VAC to the power supply unit.

AC INPUT



The power supply has two separate sections, one for each ODP unit. Thus each measurement unit can control its own section of the power supply.

Additional Connectors

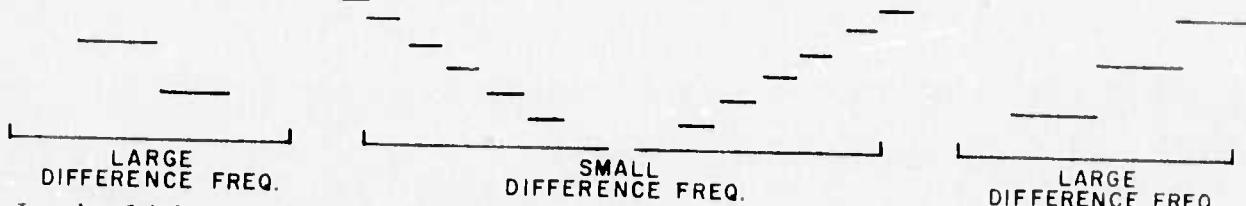
Additional connectors are provided to allow external range switching, and to enter an origin phase into the phasemeter.

2.4 Operation and System Checkout

This section describes a method which can be used to confirm that the phase measurement sections are operating correctly. The only equipment required is a pair of sine wave generators with variable frequency output between 32Hz and 192kHz, and with a reasonable short-term stability. Connect

one of the generators to the Phase Measurement A input and set its output frequency to $940\text{Hz} \pm 20\text{Hz}$ for the Infrared ODP or to $6.4\text{kHz} \pm 125\text{Hz}$ for the Visible ODP. Connect the other generator to the B input and set it for approximately the same frequency. Set the range switch (i.e., the reticle speed switch) to 60 rpm.

Using the input selector switches, route the first generator to both the measurement and the reference channels. Switch the meter to the left-hand position and notice that the pointer is approximately centered. Observe the phase measurement output on an oscilloscope and observe that the output voltage is approximately 0 volts. Now, route the second generator to the measurement channel and leave the reference channel connected to the first generator. Depending upon the frequency difference between the generators, waveforms similar to those below will be observed.



It should be possible to obtain any of these waveforms by slightly adjusting either of the generator frequencies. (At high frequencies, these adjustments are fairly delicate.) Check the Integrated Phase Change output by setting the generator difference frequency to give a fairly rapid waveform (approximately 10 steps). Observe the integrated phase change output and note that a similar waveform is present, whose period is 64 times that of the phase-change waveform. Set the generator difference frequency to give a phase change waveform of the opposite sense (rising if at first it was falling), and observe that the integrated phase change output reverses sense also, again with a period 64 times that of the phase change measurement.

Repeat the above experiment with both generators set to the frequencies shown in Table 1. It is necessary only to check the integrated phase change output at one frequency for each system.

After completing these tests and obtaining proper indications, remove both generator inputs from the measurement system. Observe that the warning lights come on and that the voltage at the output jacks drops to below -4 volts. Depress the CAL button and observe that the warning lamps extinguish and that a signal similar to that obtained when using the signal generators is present at all the output jacks.

This completes the functional checkout of the phase measurement system.

There is no convenient method of checking out operation of the MTF system. The MTF waveforms are sufficiently complex so that no simple check can determine proper operation. If difficulty with this circuitry is suspected, it will be necessary to use the schematics in conjunction with the theory of operation section to locate the fault.

The procedure for aligning the AGC system is as follows:

- 1) Apply a 50-percent amplitude modulated sinewave to the phasemeter input.
- 2) Apply the modulating signal to the scintillation input.
- 3) Adjust the amplitude of the modulated sinewave so that the amplitude of the modulation is equal to the amplitude of the modulating signal.
- 4) Adjust the scaling potentiometers in the phasemeter input AGC circuit until the modulation is a minimum at the circuit output.
- 5) Repeat for the phasemeter and MTF inputs.

The condition specified in Step 3 above must be observed during actual use of the ODP. That is, the operator must adjust the levels of the incoming measurement and scintillation signals such that the amplitude of the modulation is equal to the amplitude of the scintillation signal. If this is not possible, their ratio should be set at some convenient value and the same ratio used in Step 3.

3.0 SYSTEM SOFTWARE

3.1 General Requirements

In this section of the report we discuss the performance requirements of the software systems and indicate in a general way how they were met. These systems control the sampling, digital conversion, labeling and recording of the preprocessed optical measurement signals. The specific performance objectives which they were designed to meet were:

- 1) Sampling of the input data in real-time at the rates necessary to retain all of the desired information.
- 2) Analog-to-digital conversion of the data with high enough accuracy to prevent the loss of significant data.
- 3) Sampling and recording of an input signal, without interruption, throughout the duration of the signal.
- 4) Automatic processing of data derived from analog tape recordings, including search for the start and end of the desired segment of the input signal.
- 5) Labeling of digitized data records and files in accordance with ancillary parameters supplied to the computer via the teletypewriter.
- 6) Recording of the digitized data in a format which is compatible with the input requirements of a GE 645 Computer.

The primary signal input to the computer is the measurement data which are provided by the ODP. The ODP also provides three signals which are used by the computer during the processing of the data. These are:

- 1) A train of 1-second time marks;
- 2) A data-condition level, which is positive for calibration data and negative for optical signal data;

3) A train of uniformly spaced pulses which, for the $\Delta\phi$ and $\Delta\Delta\phi$ data, mark the occurrence of each new phase angle measurement, and for the MTF data mark the start of each new MTF cycle. These signals are entered into the computer via a multiplexer which, under control of the software, selects one of them and feeds it to the sampler.

During the performance of an experiment all four signals are recorded by the Ampex FR 106 instrumentation tape recorder onto four separate tracks on a reel of 1-inch wide magnetic tape. The data and the data-condition level are recorded in FM mode, the pulse trains in AM mode. Since the scintillation signal is obtained simultaneously with any one of the other optical measurement signals, it can be recorded on a fifth track, simultaneously with the recording of the data signal. When it is determined that the conditions for an experiment are satisfactory, the calibration button on the preprocessor is depressed for several seconds and then released. The button is again depressed at the conclusion of the experiment. The computer program will sample, convert, and record both the calibration and the real measurement data provided by the preprocessor. Thus, the digital tape recordings will contain calibration data at the beginning and end of a run. These can be used to establish the calibration of the experimental data and to correct the calibration for small drifts which may have occurred during a run.

Two software systems were developed, one for the $\Delta\phi$, $\Delta\Delta\phi$, and scintillation data (Optical 1), and the other for the MTF data (Optical 2). While they contain many of the same subroutines, they differ in the all important routine for sampling the optical data and extracting the desired information.

3.2 Techniques for Meeting the General Performance Requirements

3.2.1 Real-Time Sampling

The design of the procedures for sampling the data in real time required first a determination of whether the data signal supplied by the ODP was to be sampled synchronously or asynchronously. Asynchronous sampling is independent of the frequency of the information carrier and of the measurement rate of the preprocessor. In accordance with the Nyquist criterion, asynchronous sampling must be performed at a rate that is at least twice the information bandwidth. Synchronous sampling, on the other hand, is performed at either the frequency of the carrier, or at the rate of the data measurement outputs of the ODP.

For the scintillation signal, there was no choice but to use asynchronous sampling. The bandwidth of the scintillation data is about 2 kHz, which implies a minimum sampling rate of 4 kHz. This was easily achieved by the techniques which are described in Section 4.

The $\Delta\phi$ and $\Delta\Delta\phi$ signals could have been sampled asynchronously if the information bandwidth were known. However, since one of the objectives of the research program is to determine this bandwidth, there was no choice but to sample these data synchronously. Doing so insures that information at frequencies up to one-half the data measurement rate will be preserved. The highest phase angle measurement rate occurs for the $\Delta\phi$ data, at a reticle speed of 1800 rpm. For the IR measurements this rate is 4.7 kHz. For the VISIBLE it would be 32 kHz if measurements were made every six cycles of the square wave input to the ODP, as it is for the IR data. Since this rate is far higher than can be achieved by the PDP-8 system, the VISIBLE

$\Delta\phi$ measurements are made every 20 cycles when using the highest reticle speed, resulting in an upper measurement rate of 9.6 kHz.

Sampling of the MTF posed a different sort of problem. Because the frequency of the square-wave whose envelope is the MTF varies over a very wide range, it is not possible to sample this function synchronously. On the other hand, the information bandwidth is much wider than can be sampled asynchronously. It is desirable to preserve variations in the MTF whose duration may be only one to two percent of the full MTF cycle. Since two MTF cycles occur per reticle rotation, the bandwidth (of the smallest) of these variations, at the highest reticle speed, is $\frac{1}{0.01 \text{ cycle}} \times 2 \frac{\text{cycles}}{\text{rev}} \times 30 \frac{\text{rev}}{\text{sec}} = 6 \text{ kHz}$. To preserve this data would require a sampling rate of 12 kHz. While it is marginally possible to achieve this rate, it might not be reliable. Moreover, at that sampling rate, a reel of digital magnetic tape could store no more than two minutes worth of data. The solution to the problem of sampling the MTF data was to develop a method in which the signal is sampled asynchronously at a sufficiently high rate, but only the samples needed to define the envelope are stored. The sampling is made synchronous with the MTF waveforms by numbering the samples consecutively from the start of each waveform. Details of this procedure are given in Section 5.

3.2.2 Sampling Accuracy

The A/D converter in the PDP-8 system is capable of up to 12-bit sampling accuracy. However, the time to complete such a conversion, 35 usec, is far too great to permit achieving the desired data sampling rates. Actually, the $\Delta\phi$ and $\Delta\Delta\phi$ data which are provided by the ODP are known to be accurate to one bit in eight. Hence, sampling them with 9-bit accuracy insures that no significant errors will be introduced by the sampler. If the

MTF and scintillation data are obtained from analog tape recordings then 9-bit sampling accuracy will suffice for them also, since the dynamic range of the instrumentation tape recorder is about 42 dB (which is equivalent to 1-bit in eight). While it might be desirable to sample these data with higher accuracy when they are obtained live, it is not possible to do so and still retain real-time sampling at the highest required sampling rates. The time to complete an A/D conversion is 13.5 usec at a sampling accuracy of 9 bits. It jumps to 17 usec at 10 bits, to 25 usec at 11 bits, and to 35 usec at 12 bits. Such increases in the conversion time can be tolerated only at the lower two reticle speeds.

3.2.3 Continuous Sampling and Recording

To achieve continuous computer processing of the optical data, two equal-sized areas (data-buffers) are reserved in the computer memory. Data samples are stored in successive locations in a buffer until it is filled. Then, while the contents of the buffer are being written onto tape, the alternate buffer is filled. The ability to use the two buffers alternately for storing and recording the sample data requires that two conditions be met:

- 1) The time required to record the contents of a buffer, including the time to start and stop the tapewriter, must be less than the time required to fill the buffer.
- 2) The time required to set up the write instructions for the tapewriter controller must be less than the time between two successive data samples. Otherwise, the interval between the last sample in one buffer and the first sample in the alternate buffer will be greater than the average sampling period.

The first of these conditions is met by making the buffer size sufficiently large. The time to start and stop the tape drive is about 15 msec. Data are written onto the tape at a rate of 25 usec per 6-bit byte, which is 50 usec per computer word. Data are stored in the buffer at sampling rates up to about 10 kHz, i.e., 100 usec per sample. Therefore, the minimum length of the buffer, L, with one computer word used per sample, can be computed from

$$\text{load time} = 100 \cdot L \text{ usec}$$

$$\text{unload time} = (15000 + 50 \cdot L) \text{ usec}$$

Solving for L, we find that it is 300 words. Actually, to use the tape efficiently, the buffer size is made about 1600 words. This requires about six inches of tape per record, including the standard 3/4-inch record gap. Thus, a maximum of 4600 records can be written onto a 2400-foot reel of tape. For convenience in checking for potential tape overruns, the maximum number of records is set at 4096.

3.2.4 Automatic Processing of Analog Recorded Data

The main reason for providing automatic processing of analog recorded data is to enable the system to process corresponding time-segments of different data signals which were recorded simultaneously. For example, it may be desirable to compare the MTF data which were obtained for visible and for infra-red light at the same time, or to compare the scintillation data with one of the other data signals obtained for the same laser beam. The automatic processing technique enables the computer to locate the point at which a desired data segment begins, and to process the data for the desired duration of the segment.

To achieve this operation the user enters the following information at the start of a run:

- 1) The number of data runs which precede the one of interest.

(Actually, the number of sets of calibration data, since each run is preceded by a set of calibration data.)

- 2) The elapsed time from the start of the data run to the segment of interest.

- 3) The duration of the segment.

The computer is programmed to detect the start and end of each set of calibration or signal data and to differentiate between the two types.

When a run is begun, the analog tape is started and the program proceeds to count the number of calibration sets until the one which precedes the desired data set is detected. It then samples and records the calibration data and it counts the number of data sync pulses in a one-second interval. It uses this to compute the number of digital records that will have to be written for the selected duration of the data set. If this exceeds 4096, the maximum number that can be recorded on a reel of tape, it rewinds the digital tape, computes the maximum run duration for the observed sync-pulse rate, informs the user of that maximum, and requests that a new value of run duration be entered. If the run duration is acceptable, the program counts down the time from the end of the calibration data which precedes the desired data set to the start of the data, using the value of start time entered by the user. Time is counted down in 1-second intervals by using the 1-second time marks which were recorded onto the analog tape simultaneously with the data and sync-pulses. After the desired amount of time has elapsed, the computer proceeds to sample and record the data, using the

sync-pulses to maintain synchronous sampling of the data. Just before recording each record, the computer checks to insure that all the samples in the buffer represent signal data. If the calibration set which succeeds the selected data is encountered before the desired length of run has elapsed (i.e., if the run duration was longer than the extent of the segment of signal data that are being sampled), the computer automatically samples and records this final calibration data set and terminates the run. Otherwise, the computer continues the run until the previously calculated number of records have been written, and then searches for the calibration set which succeeds the run. After sampling and recording this set, the computer writes an end-of-file mark on the digital tape and rewinds the tape.

3.2.5 Labeling of Records

In addition to the data which the user is required to enter for automatic operation of the system, he also can enter data which are used to label and identify the run, and the conditions under which it was made. This additional, ancillary information consist of the following:

- | | |
|---------------------|---|
| Date of the run | - month, day, and year as two-digit numbers |
| Time of the run | - hours and minutes as two-digit numbers |
| Type of signal data | - a two-digit number which can be used to identify the optical data |
| Sampling accuracy | - a two-digit number corresponding to the setting of the A/D converter |
| Comments | - a statement of up to 250 words describing the condition of the experiment |

This information, together with the number of calibration sets preceding a run, the time to the start of the data set, and the duration of the run, are recorded in a digital record which is written before the run is started. During the run, the sequence number of each record is entered as ancillary data at the end of the record.

4.0 DESCRIPTION OF OPTICAL 1

In this section of the report we describe in detail the major routines which are used by the program for sampling the phase measurement and scintillation data. A complete listing of the program is presented in Appendix 2 and should be used in conjunction with the flowchart and explanations which follow. Some of the routines which are used in the program are virtually self explanatory, and so will not be described here. Included among these are the service routines for printing various messages on the teletypewriter (TTY), for reading either numbers or Hollerith data entered via the TTY, for converting from octal to binary for BCD printout of computed data, and for writing an end-of-file and rewinding the magnetic tape.

4.1 The Main-Line Routine

The main-line routine is the set of instructions, stored in locations 200 through 257, which control the flow of operations in this data sampling program. It calls upon the supporting subroutines as they may be required. A flowchart is presented in Figure 10.

The first step is a call to subroutine STRTUP which initializes certain parameters, requests the input of other parameters, and reads, stores, and records these data. Once this is accomplished, the program halts to permit the operator to check the equipment from which the optical data signal will be obtained.

When the system is ready, the operator depresses the RUN switch and the program continues with the sequence of six instructions which start with the label CALTS. Their purpose is to count down the number of sets of calibration data which precede the desired signal data. This number, entered by the operator during the STRTUP routine, is incremented by one, negated, and

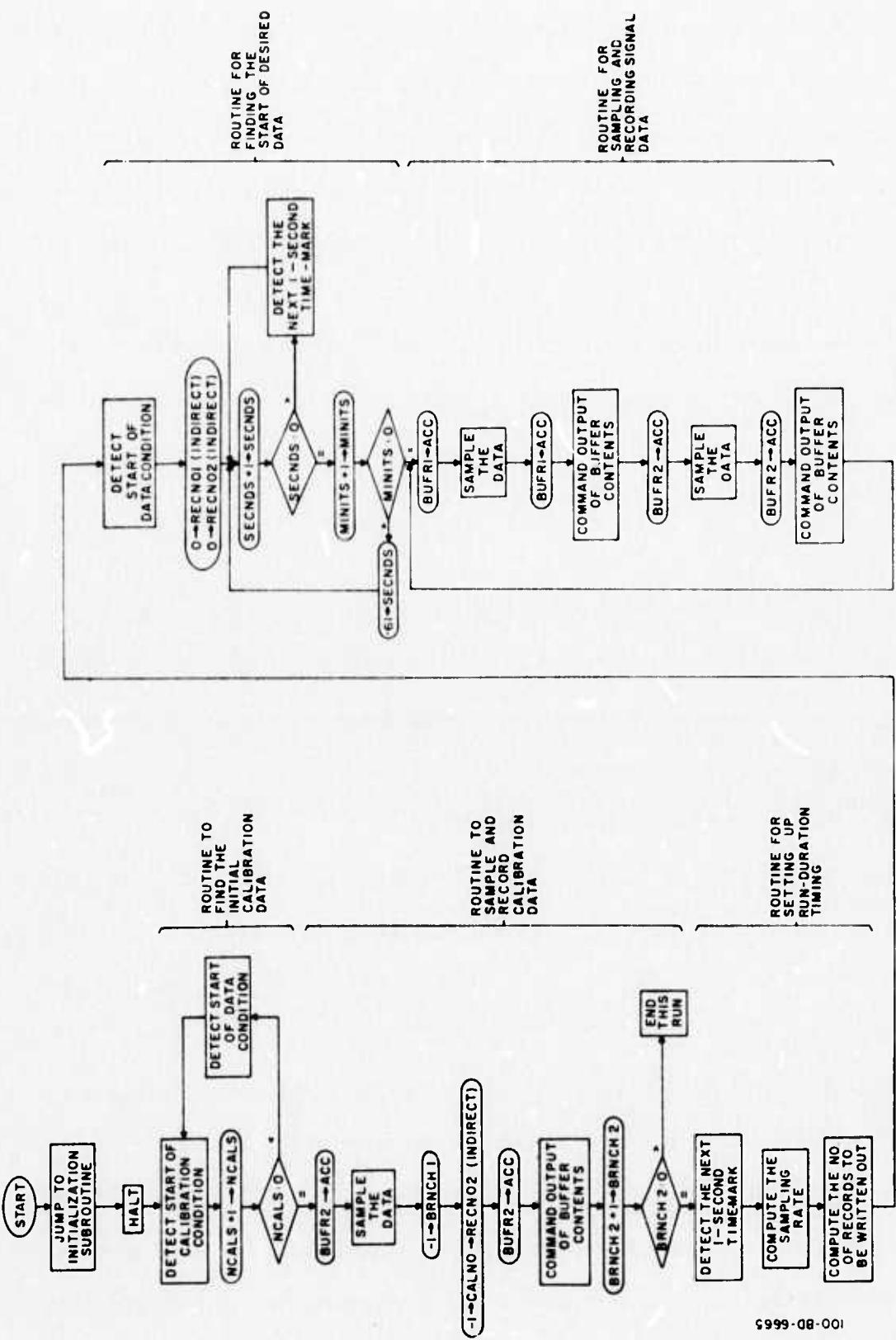


FIG. 10 EXECUTIVE ROUTINE FOR OPTICAL I

stored in NCALS (at location 1026). The start of a set of calibration data is detected by subroutine CALTST, and the end (i.e., the start of a data set) by DTATST. When NCALS reaches zero the program branches to CALSET to sample the calibration data. A -1 is stored in BRNCH1 to indicate that the calibration data were not encountered during the sampling of the desired signal data. A -1 is also stored in RECNO2, which is the address in Buffer 2 at which the record sequence number is stored. Finally, the contents of Buffer 2 are written onto tape by a call to subroutine BUFOUT. On return from this routine, BRNCH2, which was set to -1 by the initialization routine, is incremented and the mainline program skips the next instruction. At the end of the run the calibration data set which follows the signal data will be sampled and recorded. For this set a -2 will be stored in RECNO2. This time when BRNCH2 is incremented the instruction at 225 will not be skipped and the program will branch to the routine FINIS which writes an end-of-file on the digital tape and then rewinds the tape.

After writing out the initial calibration record the mainline program calls subroutine TICTOC which detects the leading edge of the next one-second mark pulse to be generated by the preprocessor. It then calls subroutine SAMPRT which determines the data sampling rate by counting the number of sample-sync pulses which are generated by the preprocessor in the next one-second interval. The program uses this information in subroutine RECONT to compute the number of records of signal data which will be written for the selected run duration. This number is negated, stored in NRECS, and counted down during the run to determine when the run should be terminated.

All of the foregoing operations are performed within the duration of the initial calibration data set. Consequently, the next instruction, at

231, is a call to DTATST to detect the start of the signal data. After clearing the addresses at which the record sequence number is stored in both buffers, the program proceeds to count down the time to the start of the desired section of the signal data. The time, in minutes from the end of the initial calibration data set, had been entered by the operator during the initialization routine. The initialization routine incremented this number by one, negated it, and stored it in STRTIM. It also stored a -1 in SECNDS. Consequently, when the set of ten instructions which begins at 234 is entered the first instruction results in a jump to MINITS where STRTIM is incremented. If the value of STRTIM has not been reduced to zero the program stores a -61 in SECNDS and returns to 234. SECNDS is incremented and then reincremented at the start of each succeeding one-second time mark until it reaches zero, when STRTIM is again incremented.

The procedure described above is repeated until STRTIM reaches zero, whereupon the program jumps to the main data-sampling routine. Here the program first loads samples into Buffer 1. When the buffer is filled, the writing out of its contents is initiated by a call to subroutine BUFOUT. At the same time, the program begins to load Buffer 2. The buffers continue to be loaded and unloaded in alternation, until the requisite number of records has been written. The program then jumps back to instruction LSTCAL, at 210, to detect, sample, and write out a record of the calibration data which follows the signal data. If the computer encounters the final set of calibration data before the value of NRECS has been counted down to zero, the sampling of signal data is automatically terminated and the program jumps to 211.

4.2 Subroutine to Sample the Data (SAMPLE, at location 302)

This subroutine samples the data on Channel 1 whenever it detects a sync pulse on Channel 0. In this way we insure that the sampling of the data will be synchronous with the availability of a new measurement by the ODP and will occur after all transients have disappeared. When the subroutine is entered the accumulator will contain the address of the first location preceding Buffer 1 or Buffer 2, whichever one is to be filled. This is deposited in the autoindexing register at location 10. The negative number of samples to be stored in the buffer, NSAMPS (= -1620), is deposited in IX1. The program then sets the multiplexer address to Channel 0 and repeatedly samples the sync-pulse signal until a positive level is detected. It then sets the multiplexer to Channel 1, samples the data signal, and stores the sample indirectly in the address indicated in location 10. The number of samples, in IX1, is incremented, and if it is not zero, the program returns to DATAIN (at 306) to detect another sync pulse. This sequence of operations is repeated until the contents of IX1 reaches zero, when the multiplexer address is set to Channel 2, in preparation for testing whether the computer encountered calibration data during the loading of the buffer. Finally, the record sequence number is incremented in both buffers and the subroutine is exited.

4.3 Subroutine to Write Digital Tape Records (BUFOUT, at location 331)

When this routine is entered the accumulator contains the address of the first location preceding the buffer which is to be unloaded. This number is stored indirectly at the address stored in CALOC for use by the Tape Controller Unit (TCU). The program also stores -1626, the negative of the number of computer words in each buffer, in WCLOC. This is counted down by

the TCU during the transfer of data. The computer is then instructed to sample the data condition line (the multiplexer address having previously been set to Channel 2 at the end of the data sampling routine). While the analog-to-digital conversion is being completed, the command word to write 556 bits per inch in odd parity on tape unit 0 is loaded into the TCU. The output of the A/D converter is then read. If it is positive, indicating that calibration data was encountered, the routine is immediately exited via BUFOUT1 without writing the data onto the tape. However, if, as expected, the A/D output was negative, indicating optical signal data, the command to write the tape, MTGO, is issued. From here on the transfer of the data in the buffer will occur automatically, under control of the TCU. Before leaving this subroutine the number of records to be written, NRECS, is incremented and, if it is not zero, a normal exit occurs. When NRECS is reduced to zero the program jumps to LSTCAL to terminate the run in a normal manner.

4.4 Subroutine to Detect the Start of a Calibration Data Set (CALTST, at location 260)

The type of data being read by the computer is indicated by a DC level on Channel 2. A negative level indicates signal data, a positive level indicates calibration data. Subroutine CALTST locates the start of calibration data by detecting the point at which the level on Channel 2 switches from negative to positive. To prevent errors in identifying the start of a calibration data set, particularly for data reproduced from analog tape recordings, a detection is confirmed only after 3247 successive positive samples have been taken following a negative sample.

4.5 Subroutine to Detect the Start of Optical Signal Data (DTATST, at location 273)

This routine is similar to the preceding one with the exceptions that a change from a positive to a negative DC level is sought and that one negative sample preceded by a positive sample is sufficient to confirm the detection.

4.6 Subroutine to Detect One-Second Time Marks (TICTOC, at location 1103)

This routine detects the leading edge of the time-mark pulse which is generated by the preprocessor. As in the case of subroutine CALTST, detection occurs when a negative sample is followed by a positive one. At the start of this routine the address at which negative samples are stored, NOTIK, is cleared. Consequently, if the first sample should be positive the decision is not made that a time-mark pulse was detected. This is necessary to insure that detection occurs only at the leading edge of the pulse.

4.7 Subroutine for Computing the Sampling Rate (SAMPRT, at location 1125)

This subroutine is called by the mainline program immediately after a time-mark pulse has been detected. When in this subroutine, the computer alternatively samples the sync-pulse data on Channel 0, and the time-mark data on Channel 3, incrementing a count each time a sync pulse is detected. Since sync-pulse rates up to 10 kHz can occur, a double-precision counter is used, with the 16 lower-order bits in SRATLO and the 16 higher-order bits in SRATHI. The count is incremented at each sync pulse until a time-mark pulse is detected.

Because the sync pulses could occur at intervals of 100 usec it was necessary to minimize the time needed to sample the time-mark data and to test for the leading edge of a time-mark pulse. This was accomplished by having the program first seek a negative time-mark level, thereby de-

tecting the end of the time-mark pulse which preceded the entry of this routine. At the first negative time-mark sample, the instructions inside the routine are altered so that the program thereafter seeks a positive time-mark level. In this way, it is not necessary to repeatedly check the polarity of the last sample each time a new one is tested, as is done in subroutine CALTST and TICTOC.

5.0 SAMPLING AND RECORDING THE MTF SIGNAL (SAMPLE, AT LOCATION 1211)

The instructions which control the sampling and recording of the MTF signal are stored starting in location 1200 (see Appendix 3). These nine instructions, which alternately load and unload the data buffers, are the same as the ones used in the mainline routine of OPTICAL 1 for acquiring and recording optical phase-angle and scintillation data. (See Figure 10 and Appendix 2, locations 247 through 257.) As in the case of OPTICAL 1, subroutine SAMPLE is entered with the accumulator containing the address of the first location preceding the buffer to be loaded.

The first step in Subroutine SAMPLE is to store this address in auto-indexing register 10. The address is then retrieved and the offset from the start of the buffer to the region where the sync-pulse peak-sample locations are stored is added to it. The sync pulses are located by relating them to the number of the MTF peak sample at which they were detected. The resulting sync-array address is then loaded into auto-indexing register 11. Next, the sample-number counter is cleared, the maximum number of sync pulses per buffer is stored in SYNCNO, and the maximum number of MTF peaks per buffer is stored in PEAKNO. (Note that both of these numbers are negative.)

At this point the program tests to see whether the previous exit from Subroutine SAMPLE was a normal one. That is, whether the program exited when the maximum permissible number of sync pulses had been counted down to zero. If it did, then a zero would have been stored in EXITST and the program therefore will begin the MTF sampling operation by a jump to the instruction labeled LOOP, at location 1264. However, if the routine had been exited because the maximum permissible number of MTF peaks per buffer had been counted down to zero (i.e., the buffer had been filled), then a -1 would have been

stored in EXITST. In that case, the program will jump to MTFTST in order to resynchronize the sampling with the start of the next MTF sync pulse. When that pulse is detected the program resumes by clearing SAMPL1, where the amplitude of the last MTF data sample is stored, ZROSLP, where a count of equal-amplitude samples is stored, and UPSLP, which is an indicator of a positive slope on the MTF signal. The program then jumps to LOOP.

5.1 The MTF Sampling Program.

The program that controls the sampling of the MTF signal is listed in Appendix 3. However, this standard listing of the program as it actually is stored in the PDP memory is not well suited for an explanation of how the program operates. A far more useful listing, in semi-flowchart form, is presented in Figure 11. The instructions are separated into sets which are denoted by square brackets on the left and braces on the right. The operation being performed or the condition encountered is indicated to the right of the square bracket. The time taken for each instruction, in microseconds, is indicated to the right of the instruction. The total time taken for the execution of a set is noted by the circled number to the right of each brace.

Entry to this routine normally occurs at the instruction labeled LOOP, at location 1264. This instruction clears the multiplexer to Channel 0 in preparation for sampling the MTF data signal. While the multiplexer is settling, the contents of the accumulator are deposited in TEMP2. (Normally, at this time the accumulator would contain the value of the previous sample of the MTF sync-pulse signal.) The accumulator is then incremented so that on the subsequent call to Subroutine DELAY, the program will idle for 10.5 usec. On return from DELAY, the program jumps to MTFSPL at 1232, which is the true start of the sampling loop.

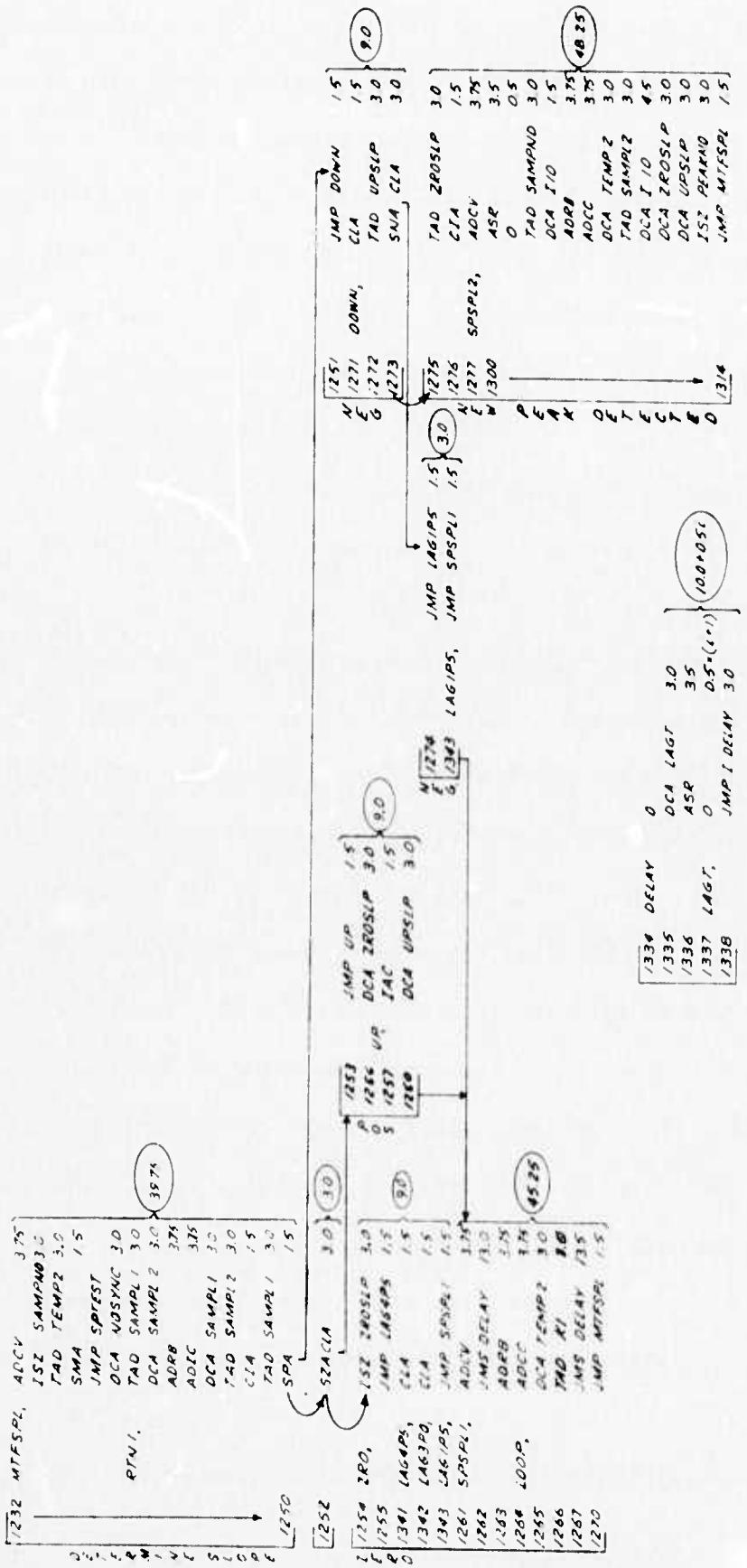


FIG II PROGRAM FLOW-PATH AND TIMING OF MTF SAMPLING ROUTINE

At this point the program samples the MTF signal line and immediately increments the sample count number (SAMPNO). While awaiting completion of the A/D conversion, the previous sync-pulse sample, stored in TEMP2, is returned to the accumulator. If the contents are positive, indicating that a sync pulse may have been detected, the program jumps to SPTEST. Otherwise, the negative value is deposited in NOSYNC to be used in a future test for a sync pulse. The program continues by transferring the previous MTF data sample from SAMPL1 to SAMPL2. It then reads the contents of the A/D buffer which by this time will contain the value of the latest MTF data sample. The multiplexer address is then incremented in preparation for sampling the MTF sync-pulse signal on Channel 1.

The next four instructions are designed to determine the slope at the sampled point on the MTF waveform. First, the contents of the accumulator are deposited temporarily in SAMPL1 and the previous sample, stored in SAMPL2, is returned to the accumulator and its value made negative. The value of the current sample is then added to the contents of the accumulator. If the sign of the resultant is negative, the program jumps to DOWN at 1271 to determine whether a new peak has been detected. If the sign was positive the program, at 1252, first checks to determine if the value of the resultant was greater than zero. If it was, the program jumps to UP where it clears the zero-slope counter (ZROSLP) and puts a 1 in the up-slope indicator (UPSLP). It then continues with instruction 1261.

If the value of the resultant was zero, the computer may have been sampling the MTF signal at a flat or very slowly changing peak. In order to properly locate the center of the peak in such a case, it is necessary to know how many successive equal-amplitude samples occurred immediately before

the peak was detected. Accordingly, the count of the number of zero-slope samples, ZROSLP, is incremented. Now, in order to make the time taken in this path equal to the time taken if the resultant had been positive, the program jumps to LAG4P5, to idle for 4.5 usec. As a result, the total time in either path is 9.0 usec.

The program continues by sampling the MTF sync-pulse signal. It then idles for a total of 13.0 usec in order to partly equalize the time taken in this path with the time taken when a new peak is detected. At the end of this delay the contents of the A/D buffer are read and the multiplexer address is cleared to zero in preparation for sampling the MTF data line. The contents of the accumulator are stored in TEMP2, the accumulator is incremented, and the program delays for 13.5 usec to complete the equalization of path timing. The program then jumps back to MTFSPL.

If, at the instruction located 1250, the computer detected that the previous sample was, in fact, larger than the current one, the program jumps to DOWN, at 1271. There, the accumulator is cleared and the current value of the up-slope indicator is obtained. If its value is zero, it indicates that this is at least the second successive sample on a downward sloping segment of the MTF signal, and that therefore a new peak has not been detected. In that case, the program jumps to LAG1P5 in order to insure that the total time taken in this path is the same as the time taken when either an up-slope or a zero-slope is detected. On the other hand, if the up-slope indicator is not zero, it indicates that the previous sample was on either a positive or zero slope and, therefore, a new peak has been passed. In that case, the program continues with the set of instructions which are stored in locations 1275 through 1314.

First, the count of zero-slope samples is brought to the accumulator where its sign is made negative. At this point, the A/D converter is commanded to begin the sampling of the MTF sync-pulse signal. The negative zero-slope count is divided by two, by shifting the contents of the accumulator one position to the right, and the current value of the sample number is added to the resultant. The number that is obtained is the sample number at which the peak was detected. Thus, if the zero-slope count was zero, the peak is located at the current sample. Alternatively, if the zero-slope count was not zero, the peak is located midway in the preceding string of equal amplitude samples. The location of the peak is stored at the address contained in auto-indexing register 10. At this point, the contents of the A/D buffer are read and the multiplexer address is set to zero in preparation for sampling the MTF signal line. The accumulator now contains the value of the current sample of the sync-pulse line. This is stored in TEMP2. Next, the amplitude of the newly detected sample is stored in the next available buffer address, as indicated by the contents of auto-indexing register 10. Finally, the zero-slope count and upslope indicator are zeroed and the count of the number of detected peaks is incremented. The program then returns to MTFSPL.

The exit routine for Subroutine SAMPLE begins at location 1320. There are two ways of getting to this point. The first, on a normal exit, occurs when the sync-pulse count has reached zero. (The negative sync-pulse counter is incremented on each detection of an MTF sync-pulse in routine SPTEST, as described in Section 5.2.) The second, or abnormal exit, occurs when the negative peak-number count, which is incremented at location 1312,

has reached zero. Should this occur, the maximum permissible number of sync pulses per buffer is reduced by one to protect against an abnormal exit on the succeeding buffer cycle. (If this number should ever reach zero, the program will halt with 7171 in the accumulator.)

The program arrives at EXIT with a -1 in the accumulator for an abnormal exit, and a zero for a normal one. The first step in the exit routine is to deposit the contents of the accumulator in EXITST for use upon the next entry to subroutine SAMPLE. It then fetches from auto-indexing register 11 the address of the last sync-pulse number to be stored in the buffer and obtains at that address the number of the last MTF signal peak to be detected. This number is then stored in Buffer 1 at the address indicated by NPKSB1, and in Buffer 2 at the address indicated by NPKSB2. The multiplexer address is then set to 2, in preparation for sampling the data condition on Channel 2 during execution of Subroutine BUFOUT. Finally, the program increments the record-number count in both buffers and then exits.

The techniques used for equalizing the running times of the program insure that whichever possible sequence of paths is taken the total time between successive samples of the MTF signal will be a constant 97.0 usec. This corresponds to a sampling rate of about 10.3 kHz, which is adequate for extracting all of the useful information in the modulation transfer function. The regularity of the spacing between samples during each MTF cycle makes it possible to accurately reconstruct the envelope of the MTF square-wave signal.

It should be noted th this point that in the event that the jump at location 1236 to test for the presence of an MTF sync pulse is executed, the time between the previous sample and the next one to be taken will be great-

er than 95.5 usec. If, in fact, a sync pulse is detected, the spacing between these two samples will be increased by 24 usec. In any event, since sync pulses occur only at the boundaries between successive MTF cycles the effect of the increased interpulse spacing would be to vary the time spacing between the origins of successive MTF waveforms. However, since such a variation could not exceed 24 usec, or one-fourth the normal sampling interval, it is apparent that this effect can be neglected.

5.2 The MTF Sync-Pulse Test (SPTEST at location 1347)

The procedure used for testing for the start of an MTF sync pulse is exactly the same as was used in OPTICAL1 for detecting the start of a 1-second time-mark pulse. However, when a sync pulse is detected this subroutine does not immediately return to the program which called it. Instead, it first increments the sync-pulse counter. If the counter has not reached zero the subroutine continues by bringing in the number of the most recent MTF peak to be detected, changes the sign of the number, and stores it at the address indicated by auto-indexing register 11. The subroutine then returns to the calling program. In the event that the sync-pulse count has reached zero, the subroutine jumps to EXIT at location 1320.

6.0 APPENDIX 1

PIN CONNECTIONS FOR EXTERNAL PHASE-ORIGIN DATA

(Connector on rear panel of the ODP)

<u>Pin</u>	<u>Data</u>
A	2^0
B	2^1
C	2^2
D	2^3
E	2^4
F	2^5
H	2^6
J	2^7
K	2^8
L	2^9
M	2^{10}
N	2^{11}
P	<u>Reset</u>
R	+5
S	Ground

- Notes:
1. External input data must be switched between 0 and 5 volts.
 2. If external inputs are used (Pins A-N) IC3 and IC7 must be removed to prevent damage.
 3. When external inputs are not used, Pin P may be grounded to produce a zero origin.

7.0 APPENDIX 2

**LISTING OF OPTICAL 1 PROGRAM
FOR SAMPLING AND RECORDING OPTICAL DATA**

LOCN CDAI LABEL LIST

♦5	CCC00	CCC00		JMP 1 2
	CCC01	5454		
	CCC02	CCC00		
	CCC03	0000	161,	
	CCC04	CCC00	162,	
	CCC05	CCC00	163,	
	CCC06	CCC00	TEMP1,	
	CCC07	CCC00	TEMP2,	
*2	CCC20	CCC00	LATE,	
	CCC21	CCC00		
	CCC22	CCC00		
	CCC23	CCC00	164,	
	CCC24	CCC00		
	CCC25	CCC00	ECODE,	
	CCC26	CCC00	ACALS,	
	CCC27	CCC00	STR16,	
	CCC28	CCC00	SUM16,	
	CCC29	CCC00	ABITS,	
	CCC30	CCC00		
	CCC31	CCC00		
	CCC32	4624	ASAPPS, -3124	
	CCC33	CCC00	AREGS,	
	CCC34	CCC00	SRATH1,	
	CCC35	CCC00	SRATH2,	
	CCC36	1523	FUFRI,	1523
	CCC37	4646	SRTH1,	4546
	CCC38	4647	SRTH2,	4547
	CCC39	4653	ARCSEL,	4650
	CCC40	4651	RECON1,	4551
	CCC41	4651	FUFRI,	4551
	CCC42	4651	SRTH2,	7774
	CCC43	4651	SRTH2,	7775
	CCC44	7774	SRTH2,	7776
	CCC45	7775	SRTH2,	7777
	CCC46	7776	SRTH2,	-3126
	CCC47	7777	SRTH2,	
	CCC48	4652	SRTH2,	
				/1626 WORDS PER BUFFER /362 GE COMPUTER WORDS)

			/ADDRESS OF NCALS IN BUFFER 1 FOR TAG WRITEOUT.
00051	1532	CALBFL, 1532	
*70			
00070	0000	ERNCH1, 0	/USED IN TESTS FOR THE INITIAL AND FINAL CAL
00071	0000	ERNCH2, 0	/GROUPS. BOTH ARE SET TO -1 INITIALLY.
00072	0000	CALNO, C	
00073	7777	SECONDS, -1	
00074	0000	CALCNT, 0	
<i>/</i>			
00075	0002	K2,	2
00076	0003	K3,	3
00077	0017	K17,	17
00100	0026	K26,	26
00101	0027	K27,	27
00102	0033	K33,	33
00103	0260	K260,	260
00104	7777	R1,	-1
00105	7776	R2,	-2
00106	7775	R3,	-3
00107	7774	R4,	-4
00110	7773	R5,	-5
00111	7767	R11,	-11
00112	7766	R12,	-12
00113	7765	R13,	-13
00114	7764	R14,	-14
00115	7703	R75,	-75
00116	7521	R257,	-257
00117	7520	R260,	-260
00120	4654	R3124,	-3124
<i>/</i>			

```

*20C   4777    JMS STARTUP      /SET PARAMETERS AND READ IN RUN DATA.
00200  7402    FLI
00201  CALIS.  JMS CALIST     /FIND THE START OF THE NEXT CAL GROUP.
00202  4260    IS? NCALS      /LAST CAL GROUP BEFORE SELECTED DATA.....
00203  2026    IS? NCALS      /LAST CAL GROUP BEFORE SELECTED DATA.....
00204  5206    JMP *+2        /NO . TRY AGAIN.
00205  5212    JMP CALSET     /YES. GO AHEAD.
00206  4273    JMS CHATST     /FIND THE END OF THIS CAL GROUP.
00207  5202    JMP CALTS     /TRY AGAIN.
/
00210  4260    LSTCAL, JMS CALIST  /DEFLECT THE FINAL CAL GROUP.
00211  4776    JMS ENDLAG    /DELAY 2.5 SEC IN CASE BUFFER 2 IS IN USE.
00212  1043    CALSET, IAD BUFR2
00213  4302    JMS SAMPLE
00214  7040    CMA
00215  3070    DCA PRNCH1   /SET BRNCH1=-1 FOR NORMAL RETURN FROM BUFCUT.
00216  2072    IS? CALNC     /CALNO = 1 FOR INITIAL CAL GROUP
00217  1072    IAD CAL4C     / = 2 FOR FINAL CAL GROUP.
00218  7041    CIA          /CHANGE SIGN OF CALNO AND STORE
00221  3447    DCA 1 RECD2   /AS RECORD #0. IN BUFFER 2.
00222  1043    IAD BUFR2
00223  4331    JMS BUFOU1
00224  2071    IS? BRNCH2   /SKIP IF THIS WAS THE INITIAL CAL GROUP.
00225  3357    JMP FINIS
/
00226  4775    JMS TICLOC     /FIND THE START OF THE NEXT ONE-SECOND TICK
00227  4774    JMS SAMPLT    /COMPUTE THE SAMPLING RATE
00230  4773    JMS RECD1    /COMPUTE THE NO. OF RECORDS FOR THIS RUN (NRECS)
00231  4273    JMS CHATST   /FIND THE END OF THIS CAL GROUP.
00232  3442    DCA 1 RECD1   /CLEAR THE RECORD NUMBER COUNTERS.
00233  3447    DCA 1 RECD2

```

/ ROUTINE TO FIND THE START OF DATA

00234	2073	STARIS, 1SZ SECNS
00235	5237	JMP *+2
00236	5241	JMP MINIS
00237	4772	JMS TICTOC
00240	5234	JMP STARIS
00241	2027	MINIS, 1SZ STARIS
00242	5244	JMP *+2
00243	5247	JMP GETDATA
00244	1115	JAC M75
00245	3073	UCA SECNS
00246	5234	JMP STARIS

/ MAINLINE ROUTINE

00247	1036	CELLIA, JAD BUFR1
00250	4302	JMS SAMPLE
00251	1036	JAD BUFR1
00252	4331	JMS BUFCUT
00253	1043	JAD BUFR2
00254	4302	JMS SAMPLE
00255	1043	JAD BUFR2
00256	4331	JMS BUFCUT
00257	5247	JMP GETDATA

/ ROUTINE TO FIND THE NEXT 1-SECOND TIME MARK.

66

/ ROUTINE TO DETECT THE START OF A CALIBRATION GROUP

00260	3036	CALIST, JAD BUFR1
00261	1036	JMS SAMPLE
00262	3074	UCA CALC1
00263	6532	ADCV
00264	4772	JMS LAG,
00265	6534	ADCV
00266	7712	SPA CLA
00267	5261	JAP *-5
00270	2074	1SZ CALCAT
00271	5263	JMP *-6
00272	5602	JEP 1 CALST

✓ CAL Group 1 IS DETECTED AFTER 3247 SUCCESSIVE POSITIVE SAMPLES ARE TAKEN ON CHANNEL 2.

ROUTINE TO DETECT THE START OF A DATA GROUP

```

00273 COCO LIAST C
00274 6532 ADCV
00275 4772 JMS LAG9
00276 6534 ADRE
00277 7700 SMA CLA
00300 9274 JMP *-4
00301 5673 JMP I DIATSI

```

ROUTINE TO SAMPLE THE OPTICAL DATA. THE A/D CONVERTER IS TRIGGERED WHEN A DATA-STROBE IS DETECTED.

```

00302 COCO SAMPLE, ECA 10 /STURE THE PRE-BUFFER ADDRESS.
00303 3010 FAD NSAMPS
00304 1032 UCA IX1
00305 3C33 /STROBES ARE ON CHANNEL ZERO
00306 6541 DATAIN, ADCC /DELAY 17 USEC TO ALLOW MAX TIME TO SETTLE.
00307 4771 JMS LAG17
00310 6532 ADCV
00311 4772 JMS LAG9 /DELAY 2 USEC TO ALLOW TIME FOR A/D CONVERSION.
00312 6534 ADCH
00313 7740 SPA CLA
00314 5310 JMP *-4 /STROBES ARE POSITIVE
00315 6544 ADIC /NO STROBE YET, TRY AGAIN.
00316 4771 JMS LAG17 /SIGNAL DATA ARE ON CHANNEL 1
00317 6532 ADCV
00320 4772 JMS LAG9
00321 6534 ADRE
00322 3440 UCA 1 10 /STURE THE SAMPLE IN THE SELECTED BUFFER
00323 2003 ISZ IX1 /HAS THE REQUIRED NO. OF SAMPLES BEEN TAKEN...
00324 5306 JMP DATAIN /N/A, SAMPLE AGAIN.
00325 6544 ADIC /YES, PREPARE TO TEST DATA CONDITION ON CH. 2
00326 2442 ISZ I RECD1 /BUMP THE RECORD NUMBER COUNTERS.
00327 2447 ISZ I RFNO2
00330 5702 JMP I SAMPLE

```

/ ROUTINE TO WRITE OUT EITHER BUFFER

0C331	C000	HUFFUL.	C
0C332	3756	LCA 1 CALOC	STORE THE PRE-BUFFER ADDRESS.
0C333	1050	TAD WDCNT	11626 WORDS TO BE WRITTEN.
0C334	3755	LCA 1 WCLOC	

0C335 6532 ADCV /SAMPLE THE DATA CONDITION ON CHANNEL 2.

0C336 1354 TAC COMMAND /UNIT 0, WRITE, ODD PARITY, 556 BPI.

0C337 6716 MTLC

0C340 7200 CLA

0C341 6534 ADRA

0C342 7700 RECLSI, SYA CLA /SKIP IF A DATA CONDITION WAS DETECTED.

0C343 5350 JMP RFOU1

0C344 6742 MTGC

0C345 2033 ISZ NRECS /TEST RECORD COUNTER TO DETERMINE IF THE
0C346 5731 JMP 1 BUFFOUT REQUIRED NO. OF RECORDS HAVE BEEN WRITTEN.

0C347 5210 JMP LSTCAL /ALMOST DONE.

0C350 2070 RFOU1, ISZ ERNC1 /SKIP IF THIS IS AN EXPECTED CAL GROUP.

0C351 5211 JMP LSTCAL+1

0C352 6722 MTGC

0C353 5731 JMP 1 BUFFOUT

0C354 C445 CCMAND, C445 /UNIT 0, ODD PARITY, WRITE, 556 BPI

0C355 7752 HCLL0, 7752

0C356 7753 CALCC, 7753

/ ROUTINE TO WRITE END-OF-FILE AND RELEASE THE TAPE

0C357 4770 FINIS, JMS MAGTS /WRITE END OF FILE.

0C360 C455 0425

0C361 4770 JMS MAGTS /RELEASING THE TAPE

0C362 C415 0415

0C363 7492 HLT

0C370 C450

0C371 1127

0C372 1155

0C373 1215

0C374 1125

0C375 1103

0C376 1200

0C377 0415

*435

/ TAPE CONTROL ROUTINE FOR ECF AND REVIEW

0C400	0000	FAGIS.	JMS ENDLAG	DELAY 200 SEC.
0C401	4776		TAD 1 MAGTS	
0C402	1600		MILC	
0C403	6716		CLA	
0C404	7200		PIGO	
0C405	6722		ISZ MAGTS	
0C406	2200		JMP 1 MAGTS	
0C407	2600			

/ ROUTINES FOR ENTRY OF PARAMETER DATA AT
THE START OF A RUN.

0C410	0000	SETUP.	JMS INITL	
0C411	4775		JMS PARMS	
0C412	4222		JMS INITL2	
0C413	4774		TAD K2	
0C414	1075		ADSC	
0C415	6542		TAD BUFFER	
0C416	1036		JMS BUFOUT	
0C417	4777		JMS PRINTD	
0C420	4773		JMP 1 STARTUP	
0C421	5610		JMS NUMBER	
0C422	0000	PARAMS.		
0C423	4772	JMS ENTER		
0C424	4771	JMS ECATE	/	XX/YY/ZZ/
0C425	4264			
0C426	7775	-3		

)
/ DATA TYPE IS ON CHANNEL 2.
/ DATA TYPE TO WRITE OUT TAG DATA
/ GO.
/ TYPE... READY
/ RETURN TO 201

/ -2

/ JMS ENTER / XX/YY/ZZ/
/ JMS TIMNOW / JMS NUMBER
/ JMS NUMBER -2

/

0C433	4772	JMS ENTER		
CC434	4767	JMS CATAIC	/	XX/
0J435	4264	JMS NUMBER		
CC436	7777	-1		
<i>/</i>				
00437	4772	JMS ENTER		
0C440	4766	JMS CALGRP	/	XX/
CC441	4264	JMS NUMBER		
CC442	7777	-1		
<i>/</i>				
00443	4772	JMS ENTER		
0C444	4765	JMS STARTM	/	MMMM/
00445	4264	JMS NUMBER		
0C446	7777	-1		
<i>/</i>				
00447	4772	JMS ENTER		
0C450	4764	JMS RNTIME	/	NNNN/
0C451	4264	JMS NUMBER		
00452	7777	-1		
<i>/</i>				
00453	4772	JMS ENTER		
0C454	4763	JMS IALTS	/	XX/
0C455	4264	JMS NUMBER		
0C456	7777	-1		
<i>/</i>				
0C457	4772	JMS ENTER		
0C460	4762	JMS CCMENTS	/	AHC012 345...../
0C461	4343	JMS ALPHAR		
0C462	4761	JMS CRLF		
CC463	5622	PRMTV. JNP 1 PARAMS		
<i>/</i>				
RECALLING TO READ IN NUMBERS WITH SLASHES AS DELIMITERS				
CC464	COJO	NUMBER.	/	
0C465	1664	TAD 1 NUMBER		FETCH NO. OF NUMBERS TO BE READ
CC466	3003	UCA IX1		
CC467	4312	NUMBER.	JMS INPUT	READ ONE DIGIT
0C470	7450	SNA		SKIP IF NOT A SLASH

0C471 5303 JMP NMBR2 /IT IS A SLASH. STORE THIS NUMBER.
 0C472 1117 TAD #260 /REMOVE ASCII CODING AND
 0C473 3007 LCA TEMP2 /STORE THE NEW DIGIT.
 0C474 1006 TAC TEMP1 /MULTIPLY SUM OF
 0C475 7425 MUL MUL /PREVIOUSLY STORED DIGITS
 0C476 C012 12 /BY 10.
 0C477 7501 FQA
 0C500 1007 TAC TEMP2 /ADD THE NEW DIGIT AND
 0C501 3006 DCA TEMP1 /STORE THE NEW SUM.
 0C502 5267 JEP NMBR1 /GO BACK FOR MORE.
 0C503 1006 NMBR2. TAC TEMP1
 0C504 3411 DCA I_11 /STORE THE NUMBER
 0C505 3006 DCA TEMP1
 0C506 2003 ISZ IX1 /ANY MORE NUMBERS TO COME.....
 0C507 5267 JEP NUMBER /YES. GO BACK FOR MORE.
 0C510 2264 ISZ NUMBER /NO. BUMP THE RETURN ADDRESS.
 0C511 5664 JMP I NUMBER /RETURN.

 / ROUTINE TO READ NUMERIC DATA IN FROM THE TTY
 0C512 C020 INPUT. O

 0C513 4335 JMS LISV /READ IN 1 ASCII CHAR. FROM TTY
 0C514 3005 DCA IX3 /STORE IT.
 0C515 1005 TAD IX3 /GET IT BACK.
 0C516 1116 TAD #257 /GREATER THAN 256.....
 0C517 7510 SPA /YES.
 0C520 5350 JMP REPEAT /NO. ASK AGAIN.
 0C521 7450 SMA
 0C522 5712 JMP I INPMO /ACCUMULATOR = ZERO. CHARACTER WAS A SLASH.
 0C523 1113 TAD #13 /LESS THAN 13.....
 0C524 7700 SMA CLA /YES. IT IS A NUMBER.
 0C525 5330 JMP REPEAT /NO. ASK AGAIN.
 0C526 1005 TAC IX3 /GET IT BACK
 0C527 5712 JMP I INPMO /DONE.
 0C530 7300 REPEAT. CLA CLL
 0C531 1264 TAD NUMBER
 0C532 1106 TAD #3
 0C533 3003 UCA IX1
 0C534 5403 JMP I IX1

ROUTINE TO READ ONE ASCII CHARACTER FROM THE I/O						
00535	C000	LISN,	C			
00536	6031	KSF				'SKIP ON KEYBOARD FLAG
00537	5336	JMP -1				
00540	6036	KRB				'READ KEYBOARD BUFFER AND CLEAR FLAG
00541	6046	TLS				'ECHO BACK.
00542	5735	JMP I LISN				
ROUTINE TO READ HULLERIT+ CHARACTERS (TERMINATION BY A SLASH)						
00543	C000	ALPHAB.	C			
00544	1077	TAD K17				
00545	1030	TAD HUFRI				
00546	3010	DCA I0				
00547	4333	ALFA1 •	JMS LISN			
00550	3006	DCA TEMP1				
00551	1006	TAD TEMP1				
00552	1116	TAD M257				
00553	7650	SNA CLA				
00554	5743	JMP I ALPHAB				
00555	1006	TAD TEMP1				
00556	3410	DCA I I0				
00557	5347	JMP ALFA1				
/						
00561	1020					
00562	C720					
00563	C7C4					
00564	0643					
00565	0664					
00566	0624					
00567	C760					
00570	C747					
00571	C613					
00572	C630					
00573	C732					
00574	1C42					
00575	1030					
00576	1200					
00577	C331					

REC	COD	ENTER.	?	JMS CRLF
00601	4777			JMS PRINT
00602	4776			
00603	7772		-D	
00604	C302			
00605	C316			
00606	C324		F	
00607	C312		E	
00610	C322		E	
00611	C240			SPACE
00612	5600	EDATE.		JMP 1 ENTER
00613	0000		O	
00614	4776		JMS PRINT	
00615	7773		-5	
00616	C304		O	
00617	C301		A	
00620	C324		T	
00621	C303		E	
00622	0240			SPACE
00623	5613			JMP 1 DDATE
00624	C300	CALGRP.	O	
00625	4776			JMS PRINT
00626	7763		-13	
00627	0303		C	
00630	C301		A	
00631	C314		L	
00632	C256		PRED	
00633	C307		O	
00634	C322		E	
00635	C320		O	
00636	3256		PRED	
00637	C316		I	
00640	C317		O	
00641	C240			SPACE
00642	5624			JMP 1 CALGRP
00643	0000	ENTER.	O	JMS PRINT
00644	4776			
00645	7763		-15	

CC646	0322		R
00647	0325		V
CC650	C315		V
00651	0240		SPACE
00652	0304		D
00653	C325		D
00654	C322		Z
00655	C301		A
00656	0324		I
00657	C311		I
00660	C317		C
00661	C316		N
00662	0240		SPACE
00663	5643		JMP I RNTIME
00664	0000	START,	C
00665	4776		JMS PRINT
00666	7765		-13
00667	0323		S
00670	C324		I
00671	C301		A
00672	C322		R
00673	C324		I
00674	C240		SPACE
00675	0324		I
00676	C311		I
00677	C312		H
00700	C305		C
00701	0240		SPACE
00702	5664		JMP I START
00703	0000	LJIS,	JMS PRINT
00704	4776		-11
00705	7767		V
00706	C316		C
00707	C317		C
CC710	C256		PRO
CC711	C240		SPACE
00712	C302		C
CC713	C311		I
CC714	C324		I

00715	C323	S	
00716	0240	SPACE	
00717	5763	JMP I LBITS	
00720	0000	CURRIS, C	
00721	4776	JMS PRINT	
00722	7770	-10	
00723	0303	C	
00724	0317	C	
00725	0315	M	
00726	0315	N	
00727	C305	E	
00730	0316	N	
00731	0324	I	
00732	0323	S	
00733	4777	JMS CRLF	
00734	5720	JMP I COUNTS	
00735	0000	PRINT0, C	
00736	4777	JMS CRLF	
00737	4776	JMS PRINT	
00740	7773	-5	
00741	0322	A	
00742	C305	L	
00743	0304	A	
00744	0304	D	
00745	0331	Y	
00746	5735	JMP I PRINTD	
00747	0000	LIMNOW, C	
00750	4776	JMS PRINT	
00751	7773	-5	
00752	C324	I	
00753	0311	I	
00754	0315	M	
00755	0305	E	
00756	C240	SPACE	
00757	5747	JMP I TIMECW	
00760	0000	DATAIC, C	
00761	4776	JMS PRINT	
00762	7766	-12	
00763	0304	D	

0C764	6261	A
0C765	6324	T
0C766	C3C1	A
0C767	C240	SPACE
0C770	C324	T
0C771	C331	Y
0C772	C340	P
0C773	C3C5	F
0C774	6243	SPACE
0C775	5760	JMP I DATA10
/		
0C776	1C09	
0C777	1020	
*1000		
/	ROUTINE TC PRINT ALPHANUMERIC CHARACTERS ON THE I/O	
O1CCC	0000	PRINT,
O1CC1	1600	JAD I PRINT
O1CC2	3003	CCA IX1
O1CC3	2203	ISZ PRINT
O1CC4	1603	GCPRT, JAD I PRINT
O1CC5	4212	JMS TYPE
O1CC6	2200	ISZ PRINT
O1CC7	2003	ISZ IX1
O1C12	5204	JMP GCPRT
O1C11	5603	JMP I PRINT
/	ROUTINE TC TYPE ONE ASCII CHARACTER	
O1C12	0000	TYPE,
O1C13	6041	TSF
O1C14	5213	JNP -1
O1C15	6246	TLS
O1C16	7300	CLA CLL
O1C17	5612	JMP I TYPE
/		
O1C20	C053	CLR,
O1C21	1227	JAD K215
O1C22	4212	JMS TYPE
O1C23	1226	JAD K212
O1C24	4212	JMS TYPE

01025	5620	JMP 1 CRLF
01026	C212	K212,
01027	S212	212
01030	CC00	K212,
01031	730)	215
01032	6002	CLA CLL
01033	6046	IOP
01034	6032	FLS
01035	1077	KCC
01036	3011	IAD K17
01037	5632	DCA 11
		JMP 1 INITI
/		
ROUTINE TO WRITE OUT TAG DATA		
01040	2000	INIT2.
01041	1112	IAD N12
01042	3033	DCA IX1
01043	1077	IAD K17
01044	3010	DCA IC
01045	1036	IAD E0F-1
01046	3011	DCA 11
01047	1410	IAD I 10
01050	3411	DCA I 11
01051	2003	ISZ IX1
C1052	5247	JMP .-3
		/NO. GO BACK FOR MORE.
/		
INCREMENT MCALS AND STARTIM, AND CHANGE THEIR SIGNS		
01053	1027	IAD STARTIM
01054	7040	CMA
01055	3027	DCA STRIM
01056	1026	RESIM, TAG MCALS
01057	7040	CMA
01060	3020	DCA MCALS
01061	1124	IAD N1
01062	3070	DCA BRNCH1
01063	1104	IAD N1
01064	3071	DCA BRNCH2
01065	1124	IAD N1
01066	3073	DCA SECNCES
01067	3033	DCA NRECS

ROUTINE HERE AFTER ERROR ROUTINE.

01070	3034	SRA THI
01071	3035	DCA SRA THI
01072	3072	DCA CAL MC
01073	3442	DCA I REC NO 1
01074	3447	DCA I REC NO 2
01075	1355	TAO TICK SP
01076	3350	DCA TOC JPP
01077	1302	TAO TICKER
01100	3347	DCA TICK PP
01101	5640	JMP I INIT? / 00 JE.
01102	5351	TICKER, 5351

/ ROUTINE TO DETECT ONE-SECOND TICKS



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01103	C0J0	TICKOC, C
C1104	3324	DCA ACTIK
01105	1076	TAD K3
01106	6542	ABSC
01107	4357	ONE-SECOND TICKS ARE ON CHANNEL THREE
01110	6532	TIC,
01111	4365	JMS LAG 9
01112	6534	ADDR
01113	7500	SMA
01114	5317	JYP ICC
01115	3324	DCA ACTIK
01116	5310	JYP TIC
01117	7220	TOC,
01120	1324	TAC ACTIK
C1121	7730	SMA CLA
/		/ A NEW TICK WAS DETECTED IF THE
01122	5310	PREVIOUS SAMPLE IS NOT IK
01123	5703	/ GO BACK AND LOOK FOR A POSITIVE SAMPLE.
01124	0000	NOTIK, C

/ ROUTINE TO MEASURE THE SAMPLING RATE

C1125	CC00	SAMP1, C
01126	6541	SRT1, ABC

/ STUFFERS ARE ON CHANNEL ZERO.

```

01127 4357 JMS LAG17 /DELAY 17 USEC FOR THE MUX TO SETTLE.
01130 6532 ADCV /SAMPLE THE STROBE DATA.
01131 4365 JMS LAG9 /DELAY 9 USEC TO ALLOW TIME FOR A/D CONVERSION.
01132 6534 ADRS
01133 7710 SPA CLA /SKIP IF A STROKE WAS DETECTED.
01134 5330 JMP *4
01135 1076 TAC R3 /PREPARE TO SAMPLE ONE-SECOND TICKS ON CH 3.
01136 6542 ADCV
01137 2035 ISZ SHA10 /BUMP THE LOW-ORDER SAMPLING RATE COUNT.
01140 5242 JMP *2
01141 2034 ISZ SHAI1 /BUMP THE HIGH-ORDER SAMPLING RATE COUNT.
01142 4357 JMS LAG17 /DELAY 17 USEC FOR MUX TO SETTLE.
01143 6532 ADCV /SAMPLE CHANNEL 3.
01144 4365 JMS LAG9
01145 6534 ADRS
01146 7710 SPA CLA /SKIP IF TICK LEVEL IS STILL POSITIVE.
01147 5351 TICJMP, JMP *2 /TICK LEVEL IS NEGATIVE.
01150 5326 IOCJMP, JMP SRT1
01151 1350 TAD TCC JNP
01152 3347 CCA TIC JNP /NOW, TO END SAMPLING RATE COUNT AT THE NEXT TICK.
01153 1356 TAD TCC SKP /CHANGE TICJMP TO JMP SRT1
01154 3350 DCA TCC JNP /AVL
01155 5326 TICSKP, JMP SRT1 /CHANGE IOCJMP TO JMP 1 SAMPLE
01156 5725 TUCSKP, JMP 1 SAMPLE
/
/ DELAY ROUTINES TO ALLOW TIME FOR SETTLING OF THE MUX
/ AND COMPLETION OF THE A-D CONVERSION OF THE DATA SAMPLES.
/
01157 COCO LAG17, 0
01160 7300 CLA CLL
01161 7412 ASR
01162 0000
01163 1357 TAC LAG17
01164 5370 JMP LAG01I
01165 COCO LAG9, 0
01166 7200 CLA
01167 1365 TAD LAG9
01170 3372 TAGOUT, DCA LAG17

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01171 5772 JMP I LAGRN
01172 0000 LAGRIN.

/*
*12CC

/ ROUTINE TO DELAY 200 MILLISECONDS

01200 C00C ENLLAG.

C1201 1114 TAD #14
01202 30C3 DCA #1
C1203 1043 ENL0UP, TAD BUFR2
01204 301C DCA 10

01205 1120 TAD #3124
01206 3034 DCA IX2
01207 3410 DCA 1 1) /THIS LOOP CLEARS
01210 20C4 IS? IX2 /THE SAMPLE STORAGE AREA
C1211 5207 JMP .-2 /IN BUFFER 2.
C1212 2003 ISZ IX1
01213 5203 JMP ENLCCP
C1214 5630 JMP I ENLLAG

/ CALCULATION OF THE NUMBER OF RECORDS IN THE RUN

C1215 0000 RECN1.

01216 1072 TAD K2 /PREPARE TO SAMPLE THE DATA CONDITION
01217 6542 H0SC /AFTER RETURNING FROM THIS ROUTINE.
01220 7293 CLA
01221 1030 TAD RUNTIN /TO COMPUTE THE NO. OF RECORDS (NRECS).
01222 3222 DCA #P1 /THE ROUTINE (IN MINUTES) IS
01223 1C35 TAD SRATL /MULTIPLIED BY THE SAMPLING RATE
01224 7425 SCL PUY /IN SAMPLES-PER-SECOND) AND DIVIDED
01225 C000 RPY1.
01226 3016 DCA TEMP1
01227 7731 CLA NQA
01230 3007 DCA TEMP2
01231 1030 TAD RUNTIN
01232 3232 DCA #P2
01233 1C34 TAD SRATL

01234	7425	PPY2.	PPY2.	CLA MCA
01235	0000			FAD TEMP1
01236	7701			BCA TEMP1
01247	1000			FAD TEMP1
01240	3006			BCA TEMP1
01241	1006			FAD TEMP1
01242	7040			CNA
01243	1102			FAD K33
01244	7740			SPA CLA
01245	5306			JNP ERQ1
01246	1102			FAD K33
01247	3255			DCA CIV1
01250	3003			CLA IX1
01251	1007			FAD TEMP2
01252	7421			MCL
01253	1006			FAD TEMP1
01254	7427			CLA
01255	0000	CIV1.		CLA RAL
01256	7104			CIA
01257	7041			FAD K33
01260	1102			SPA CLA
01261	7710			ISZ IX1
01262	2003			MCA
01263	7501			FAD IX1
01264	1003			DCA IX1
01265	3033			DCA IX1

2

/ STORE SAMPLING RATE AND NUMBER OF RECORDS IN THE RUN
/ IN THE OUTPUT BUFFERS

01266	1034			FAD SRAT1
01267	3037			BCA SRAT1
01270	1034			FAD SRAT1
01271	3044			BCA SRAT2
01272	1035			FAD SRAT2
01273	3040			BCA SRAT1
01274	1035			FAD SRAT1
01275	3042			BCA SRAT2
01276	1033			FAD SRAT2

01277	3441	DCA 1 NRCSS1
01300	1033	IAD NRECS
01301	3446	UCA 1 NRCSS2
01302	1033	IAD NRECS
01303	7041	CIA
01304	3033	DCA NRECS
01305	5615	JMP 1 RECDIT

/
/ ERROR ROUTINES IN CASE THE SELECTED RUN DURATION IS TOO LONG.

01306	0000	ERQULL
01307	4777	JWS WAIT
01310	C415	C415
01311	4770	JWS MAXTIME
01312	4767	JWS RCDHIN
01313	4325	JWS ERMSG
01314	4776	JWS ENTER
01315	4775	JWS RNTIME
01316	1161	IAD K27
01317	3011	UCA 11
01320	4774	JMS NUMBER
01321	7777	-1
01322	1421	IAD 1 CALBFI
01323	3226	UCA NCAALS
01324	5773	JWP RESTRT

/
/ ROUTINE TO PRINT THE ERROR MESSAGE

01325	C000	ERMSG
01326	4772	JMS CRLF
01327	4772	JMS CRLF
01330	4354	JWS MAX
01331	4775	JWS RNTIME
01332	4354	JWS IS7727
01333	5725	JWP 1 ERMSG
01334	C000	ERMSG
01335	4771	JMS PRINT
01336	7764	-14

01337	0324	1
01340	0310	n
01341	0305	L
01342	C240	SPACE
01343	C315	E
01344	C3C1	A
01345	C330	X
01346	C311	I
01347	C315	E
01350	C322	U
01351	C312	X
01352	C240	SPACE
01353	5734	JMP I MAX
01354	C00C	15L222, 0
01355	4771	JMS PRINT
01356	7771	-7
01357	C211	I
01360	C323	S
01361	C240	SPACE
83	01362	0003 DEC3, 0
	01363	C002 DEC4, 0
	01364	C002 DECA, 0
	01365	C002 DECA, 0
	01366	5754 JRP I 15L222,
	/	
	01367	1430
	01370	1400
	01371	1000
	01372	1020
	01373	1C56
	01374	0464
	01375	0643
	01376	0600
	01377	C4C0
	*14CC	/

/ ROUTINE TO COMPUTE THE MAXIMUM RUN DURATION.

```

01496 0000  MAXIM, 0
01497 7201  CLA TAC      /STORE 1 IN DIVID.
01498 3225  DCA CIVIC2   /PREPARE TO SCALE THE SAMPLING RATE UNTIL
01499 1035  TAD SRATLC  /IT IS A 12-DIT NUMBER OR SMALLER.
014A0 7421  MQL
014A1 1C34  TAD SRATHI
014A2 7450  TEST, SNA    /IS SAMPLING RATE LESS THAN 4996.....
014A3 5214  JMP CCMP1    /YES.
014A4 7417  LSR          /NO. DIVIDE THE RATE BY 2.
014A5 0000  0
014A6 2225  ISZ CIVIC2  /INCREMENT THE SCALE DIVIDER.
014A7 5206  JMP TEST    /REPEAT THE TEST.
014A8 7701  CCMP1, CLA MGA
014A9 3222  DCA DIVID1  /STORE THE SCALED SAMPLING RATE IN DIVID1.
014A10 7040  CMA          /MULTIPLY THE MAXIMUM NO. OF
014A11 7425  MQL MUY    /RECORDS (4955) BY 27.
014A12 0033  33
014A13 7407  DIVI        /AND DIVIDE BY THE SCALED
014A14 0000  CIVID1, 0    /SAMPLING RATE.
014A15 7200  CLA          /NOW DIVIDE BY THE SCALE
014A16 7437  DIVI        /DIVIDER.
014A17 7425  MQL MUY    /HOLD THE COMPUTED MAXIMUM RUN TIME.
014A18 5603  JMP I MAXIM
014A19 0000  ECMLIN, 0
014A20 7407  DIVI
014A21 1750  1750
014A22 3056  DCA TEMP1
014A23 7501  MQL
014A24 1133  TAD K260
014A25 3661  DCA I DECIMS
014A26 1006  TAD TEMP1

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/ ROUTINE TO CONVERT OCTAL TO BINARY NUMBERS AND FORMAT
FOR BCD PRINTOUT.

```

014A27 0000  ECMLIN, 0
014A28 7407  DIVI
014A29 1750  1750
014A30 3056  DCA TEMP1
014A31 7501  MQL
014A32 1133  TAD K260
014A33 3661  DCA I DECIMS
014A34 1006  TAD TEMP1

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01440	7421	FCL	
01441	7427	DVI	
C1442	C144	I44	
C1443	3036	BCA 1 FMP1	
C1444	7501	K24	
01445	1163	FAD K260	
C1446	3632	BCA 1 DECIM2	
01447	1006	FAD FMP1	
01450	7421	FCL	
01451	7427	DVI	
01452	0012	I2	
C1453	1153	FAD K260	
01454	3664	BCA 1 DECIM2	
01455	7504	K24	
01456	1103	FAD K260	
01457	3663	BCA 1 DECIM1	
01460	5635	JNP 1 BCDBIN	
/			
01461	1362	DECIM3, DEC3	
01462	1363	DECIM2, DEC2	
01463	1364	DECIM1, DEC1	
01464	1365	DECIM0, DEC0	

8.0 APPENDIX 3

LISTING OF PROGRAM

FOR SAMPLING AND RECORDING MTF DATA

/ MAINLINE ROUTINE

01200	1033	GETCIA, TAD BUFR1	JMS SAMPLE
01201	4211		TAD BUFR1
01202	1033	JMS BUFR1	/WRITE OUT BUFR1
01203	4132	TAD BUFR2	
01204	1037	JMS SAMPLE	
01205	4211	TAD BUFR2	
01206	1037	JMS BUFR1	/WRITE OUT BUFR2.
01207	4132	JMP GETCIA	
01210	5270		
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01211	COCO SAMPLE, C	/STORE THE BUFFER ORIGIN	
01212	3010	DCA 10	
01213	1010	TAD 10	
01214	1126	TAD SYNCY	/COMPUTE AND STORE THE ORIGIN OF
01215	3011	DCA 11	THE SYNC-SAMPLE LOCATION ARRAY.
01216	3122	DCA SAMPLE	/CLEAR THE SAMPLE COUNTER.
01217	1113	TAD NSYNC	I = MAX. NO. OF SYNC-PULSES PER BUFFER.
01218	3125	DCA SYNCNO	I = -MAX NO. OF PEAKS PER BUFFER.
01221	1112	TAD NEPEAK	
01222	3117	DCA PEAKNO	
01223	2070	ISZ EXITJ	/ = 0 FOR NORMAL EXIT FROM PRECEDING BUFFER.
01224	5264	JMP LCOP	
01225	4777	JMS MFTFSI	/RESET CHANNELIZE. START AT THE NEXT MTF SYNC OUTLE.
01226	3120	DCA SAMPLE	
01227	3131	DCA ZROSPL	/CLEAR THE EQUAL-AMP. SAMPLE COUNTER.
01230	3127	DCA UPSLP	/CLEAR THE SLOPE INDICATOR.
01231	5264	JPP LCOP	
01232	6532	MFSPL, ADCV	/SAMPLE THE MTF DATA.
01233	2122	ISZ SAMPLE	/INCREMENT THE SAMPLE COUNT
01234	1007	TAD TEMP2	/FEED THE SYNC-PULSE SAMPLE.
01235	7500	SVA	/SKIP TO NEW SYNC-PULSE.
01236	5347	JNP SPTEST	
01237	3115	DCA NSYNC	/STORE THE NEGATIVE SYNC-PULSE SAMPLE.
01240	1120	TAD SAMPLE	/SHIFT THE PREVIOUS SAMPLE
01241	3121	DCA SAMPLE	/DOWN ONE LEVEL.
01242	6534	ADD	/READ THE NEW DATA SAMPLE.
01243	6544	ADC	/MUX = 1)
01244	3120	DCA SAMPLE	/STORE IT.

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01245 1121 TAD SAMPLE 2 /FETCH THE PREVIOUS SAMPLE.
01246 7C41 CIA /CHANGE ITS SIGN
01247 1120 TAD SAMPLE /AND ADD THE NEW SAMPLE.
01250 7510 SPA /SKIP IF THE SLOPE IS ZERO OR POSITIVE.
01251 5271 JMP CCW'N /TEST FOR A POSSIBLE PEAK.
01252 7643 S24 CLA /SKIP ON ZERO SLOPE.

01253 5256 JMP UP /INCREMENT THE COUNTER OF EQUAL-AMPL. SAMPLES.
01254 2131 ZROSLP 157 /ZROSLP /DELAY 4.5 USEC AND RETURN TO SPSPL.
01255 5341 JMP LAGPS /CLEAR THE ZERO SLOPE COUNTER.
01256 3131 UP, DCA ZROSLP /SET THE UPSLOPE INDICATOR TO 1.
01257 7001 TAC
01260 3127 DCA UPSLP /
01261 6532 SPSPL, ADCV /SAMPLE THE MIF SYNC-PULSE LINE.
01262 4334 JMS DELAY /IDLE 1/0 USEC.
01263 6534 ADRA /READ THE SYNC-PULSE SAMPLE.
01264 6541 LCUP, ADCC /IMUX = 2
01265 3007 DCA TEMP2 /TEMPORARILY STORE THE SYNC-PULSE SAMPLE.
01266 70C1 TAC
01267 4334 JMS DELAY /IDLE 1/0 USEC.
01270 5232 JMP MFSPL /GO BACK TO SAMPLE THE MIF DATA.

/
01271 1127 CONN, TAD UPSLP /FETCH THE UPSLOPE INDICATOR.
01272 76D0 SVA CLA /A PEAK IS HERE IF A PRECEDING SLOPE WAS POS.
01273 5342 JMP LAG3P0 /END PEAK HERE. WE ARE ON A DOWNSLOPE.)
01274 1131 TAD ZROSLP /THE LOCATION OF THE PEAK IS THE CURRENT
01275 7041 CIA /SAMPLE NO., MINUS 1/2 THE COUNT OF THE
01276 6532 SPSPL, ADCV /SAMPLE THE SYNC-PULSE LINE)
01277 7415 ASR /SUCCESSIVE EQUAL-AMPLITUDE SAMPLES.
01300 COCO 6 TAD SAMPLC /
01301 1122 DCA 1 10 /STORE THE PEAK LOCN. IN THE NEXT BUFFER SLOT.
01302 3412 ADDR /READ THE SYNC-PULSE SAMPLE.
01303 6534 ADCC /IMUX = 2
01304 6541 DCA TEMP2 /AND STORE IT TEMPORARILY.
01305 3007 TAD SAMPL2 /STORE THE AMPLITUDE OF THE PEAK IN THE
01306 1121 DCA 1 10 /NEXT AVAILABLE BUFFER SLOT.
01307 3413 CCA ZROSLP /CLEAR THE EQUAL-AMPLITUDE SAMPLE COUNTER.
01310 3131 CCA UPSLP /CLEAR THE UPSLOPE INDICATOR.
01311 3127 IS2 PFAKAC /INCREMENT THE PEAK NUMBER COUNTER.
01312 2117 JMP MFSPL /GO BACK TO SAMPLE THE MIF DATA.
01313 5232

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/

/ * THE BUFFER IS FULL.

01314	2113	157 AF SYNC	/ DECREMENT THE MAXIMUM JUMPER OF SYNC PULSES.
C1315	5320	J62 +3	

01316 1107 / SOME INPUT IS SWING. THE NUMBER OF

01317 7402 FLT / SYNC-PULSE IS DOWNGOING IN ZERO.

/ C1320 3670 EXIT, UCA EXIST / INDICATE THE KIND OF EXIT.

C1321 1011 TAG 11 / FETCH THE ADDRESS OF THE FINAL PEAK NUMBER.

C1322 3003 UCA IX1

C1323 1403 TAG I IX1 / FETCH THE FINAL PEAK JUMPER,

01324 3434 UCA I IX1

C1325 1403 TAG I IX1 / AND STORE IT

01326 3440 UCA I IX1

01327 1674 TAG K2 / IN BQUE BUFFERS.

01330 6542 AGSC.

21331 2436 ISZ I RLC401 / SET FAIR = 2 TO SAMPLE THE DATA CONDITION.

01332 2442 ISZ I RLC402

C1333 5611 JNP I SAMP1

/

/ * * DELAY ROUTINES **

C1334 0000 DELAY, UCA LAGT

C1335 3337 UCA LAGT

01336 7415 ASR

01337 0000 LAGL, G

01340 5734 JNP I DELAY

/

01341 7200 LAGLP, ULA

01342 7200 LAGLP, CLA

C1343 5261 JNP SPSPL1

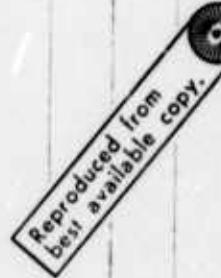
/

C1344 0000 LAGLT, C

01345 4334 JMS DELAY

C1346 5744 JNP I LAGLT

/



01347	7230	SPI TEST,	CLA	
01350	1115	IAD NC SYNC		/A SYNC-PULSE IS HERE IF LAST S-P WAS NEGATIVE.
01351	7700	SMA CLA		/NO SYNC PULSE HERE. RETURN TO THE MAINLINE.
01352	5240	JMP RTNL		
01353	3115	DCA NC SYNC		/A SYNC-PULSE IS HERE. CLEAR NOSYNC.
01354	2125	ISZ SYNCNO		/INCREMENT THE COUNTER OF SYNC PULSES.
01355	5357	JMP +2		/SKIP IF NOT THE LAST SYNC-PULSE.
01356	5320	JMP EXIT		/SYNCNO=3. PERFORM A NORMAL EXIT.
01357	1117	IAD PEAKNO		/FETCH THE CURRENT PEAK NUMBER.
01360	7041	CIA		/CHANGE ITS SIGN.
01361	3411	DCA 1 1 1		/AND STORE IT IN THE BUFFER.
01362	5240	JMP RTNL		/RETURN TO THE MAINLINE ROUTINE.
/	0341			